THE PROVINCE OF ONTARIO

A Submission to the
United States Environmental Protection Agency
Opposing Relaxation of SO_2 Emission Limits in
State Implementation Plans
and Urging Enforcement

March 12, 1981
Expanded March 27, 1981

Ontario
Ministry of the Environment
Hon. Keith C. Norton, Minister
Graham W. S. Scott, Q.C., Deputy Minister

EXPANDED MARCH 27, 1981

This submission to the U.S. Environmental Protection Agency is an expanded version of Ontario's March 12, 1981 document which opposes the proposed SIP emissions that would substantially increase SO_2 emissions at 18 power plants in six states and thereby, damage Ontario's environment. This expanded document now also addresses the Matter of Proposed Revisions to the Ohio State Implementation Plan, namely Sulphur Dioxide Emission Limits for the Eastlake and Avon Lake Plants of the Cleveland Electric Illuminating Company, Docket No. 5A-79-1.

Ontario has decided to submit this expanded version, including all 20 plants, rather than make a separate submission concerning the two Cleveland area plants. Such a separate submission would have extensively cross-referenced the earlier document. By integrating the March 12, 1981 data with new information pertinent to the cases, all evidence is hereby presented in a single document.

BEFORE THE

ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C.

In the Matter of Proposed Revision to the Ohio State Implementation Plan: Ohio Sulphur Dioxide Control Plan (OAC Chapter 3745-18 Sulphur Dioxide Standards); and	:	Docket No. 5A-80-3
In the Matter of Proposed Revision to the Ohio State Implementation Plan: Sulphur Dioxide Emission Limit for the Toledo Edison Bayshore Plant; and	:	Docket No. 5A-75-6
In the Matter of Proposed Revision to the Ohio State Implementation Plan: Sulphur Dioxide Emission Limits for the Eastlake and Avon Lake Plants of the Cleveland Electric Illuminating Company; and	:	Docket No. 5A-79-1
In the Matter of Proposed Revision to the Illinois State Implementation Plan: Sulphur Dioxide Emission Limit for the Illinois Power Company Baldwin Steam Electric Plant; and	:	
In the matter of Proposed Revision to the Indiana State Implementation Plan: Sulphur Dioxide Emission Limits for Major Coal-Fired Electric Plants and Non-Attainment Plan; and	:	
In the Matter of Proposed Revision to the West Virginia State Implementation Plan: Sulphur Dioxide Emission Limit for the Ohio Power Company Kammer Plant; and	:	
In the Matter of Proposed Revision to the Tennessee State Implementation Plan: Sulphur Dioxide Emission Limit for the Tennessee Valley Authority Kingston Plant; and	:	
In the Matter of Proposed Revision to the Michigan State Implementation Plan: Sulphur Dioxide Emission Limit for the Consumers Power Company Cobb Plant; and	:	
In the Matter of Approval of Revision to the Michigan State Implementation Plan: Sulphur Dioxide Emission Limit for the Consumer Power Company J.H. Campbell Plant.	:	

SUBMISSION OF THE PROVINCE OF ONTARIO URGING DISAPPROVAL OF PROPOSED REVISION OF STATE IMPLEMENTATION PLANS AND URGING RECONSIDERATION OF APPROVED REVISIONS AND COMMENTS

Submitted by:

J. Neil Mulvaney, Q.C.
Director
Legal Services Branch
Ministry of the Environment
of the Province of Ontario
135 St. Clair Avenue West
TORONTO, Ontario
M4V 1P5

- and -

Donnelly W. Hadden
Attorney & Counselor at Law
735 Griswold Street
Detroit, Michigan, 48226

For further information contact

Mr. E. W. Piche
Coordinator, Acidic Precipitation
in Ontario Study
Ministry of the Environment
of the Province of Ontario
TORONTO, Ontario
M4V 1P5
Phone: 416-965-2214
or 965-2440

March 12, 1981

(Expanded: March 27, 1981)

TABLE OF CONTENTS

CHAPTER		PAGE
1.	INTRODUCTION	1
2.	BACKGROUND INFORMATION	3
	2.1. Ontario's People and Environment	3
	2.2. Sources Subject to these Proceedings	6
3.	ONTARIO SHOULD BE HEARD IN THESE PROCEEDINGS	21
	3.1. The Administrative Procedures Act	21
	3.2. Decisions of U.S. Courts	23
	3.3. Proceedings under Section 115 Clean Air Act	25
	3.4 Access under International Law	26
	3.5 Stage of the Proceedings	27
4.	LAW	29
	4.1. Rights Conferred by Accords	29
	4.2. Duty of State to Protect Other States from Injurious Acts	32
	4.3 Section 115 Clean Air Act, Basis of Substantive Law	35
5.	ESTABLISHING THE CAUSES OF ACID DEPOSITION IN ONTARIO	40
	5.1 Introduction	40
	5.2. Description of Weather Systems Affecting Ontario	42
	5.3 Dry Acid Deposition and the Weather	43
	5.3.1 Background	43
	5.3.2 Evidence of Contributions from Southerly and Northerly Sources	44
	5.3.3 Specific examples of Pollution from the South	45
	5.4 Wet Acid Deposition and the Weather	51
	5.4.1 Background	51
	5.4.2 Measuring Acidity in Precipitation	52
	5.4.3 Evidence of Contributions from Southerly and Northerly Sources	53
	5.5 Summary	57

TABLE OF CONTENTS

CHAPTER			PAGE
6.	EFFECTS OF ACID DEPOSITION ON ONTARIO'S AQUATIC SYSTEMS		63
	6.1. General Nature of the Lake and River Acidification Process		63
	6.2. Research Approach to Aquatic Effects		65
	6.3 Observed Effects of Acid Rain in Ontario		69
	6.3.1	Water Quality	69
	6.3.2	Ground Water	76
	6.3.3	Fisheries Damage	79
	6.3.4	Mercury in Fish	84
	6.3.5	Leaching of Aluminum	90
	6.3.6	Algal Growth	91
	6.3.7	Amphibians	92
	6.4 Summary of Water Quality Effects		92
7.	SIGNIFICANCE TO ONTARIO OF THE EMISSIONS FROM THE 20 POWER PLANTS		97
	7.1. How the Contributions are Assessed		97
	7.2. Actual 1979 Emissions and their Contributions to Ontario's Wet Deposition		101
	7.3. Contributions Occurring if the SIP's Had been Obeyed		102
	7.4 Contributions Which Will Occur if Emissions Rise to the New Proposed Limits		108
	7.5 Summary		112
8.	ONTARIO'S ACTIVITIES TO REDUCE SO_2 EMISSIONS		114
	8.1. Cutbacks of Sources within Ontario		114
	8.1.1	INCO Ltd. Operations, Sudbury	114
	8.1.2	Falconbridge Nickel Mines Limited	117
	8.1.3	Ontario Hydro	118
	8.2. Negotiation of Agreement Leading to Abatement		122
	8.3 Interim Activities		124
9.	REMEDIES SOUGHT		129

LIST OF FIGURES, TABLES, MAPS AND EXHIBITS

	PAGE
Map 2.1	4
Table 2.1	8
Map 2.2	10
Table 2.2	11
Table 2.3	12
Table 2.4	14
Table 2.5	17
Table 2.6	19
Figure 5.1	48
Figure 5.2	49
Figure 5.3	50
Figure 5.4	55
Figure 5.5	56
Figure 6.1	67
Table 6.1	72
Figure 6.2	73
Figure 6.3	74
Table 6.2	77
Figure 6.4	80
Figure 6.5	81
Figure 6.6	82
Figure 6.7	85
Figure 6.8	88
Table 7.1	98
Figure 7.1	99

LIST OF FIGURES, TABLES, MAPS AND EXHIBITS

	PAGE
Figure 7.2	100
Figure 7.3	103
Figure 7.4	104
Table 7.2	105
Figure 7.5	106
Figure 7.6	107
Figure 7.7	109
Figure 7.8	110
Figure 7.9	111
Exhibit 8.1	115
Table 8.1	119
Exhibit 8.2	120

REFERENCES BY CHAPTER

	PAGE
Chapter 3	28
Chapter 4	39
Chapter 5	59
Chapter 6	95
Chapter 7	113
Chapter 8	128

BEFORE THE

ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C.

1.

INTRODUCTION

The Province of Ontario urges the Environmental Protection Agency (EPA) to disapprove any proposed revisions to State Implementation Plans in these proceedings which would lead to increases in allowable sulphur dioxide emissions from the power plants which are the subject of these proceedings. Where revisions have been approved by EPA, Ontario urges that these be reconsidered and no revisions be allowed which would lead to increased SO_2 emissions. Ontario also makes comments in these proceedings.

Ontario seeks the results urged by it on the basis of:

(a) Rights conferred by accords

(b) Principles of international law; and

(c) Section 115 of the Clean Air Act.

Ontario says that the power plants subject to these proceedings significantly contribute to acid deposition in Ontario. Current levels of deposition already result in harmful effects on Ontario's lakes and aquatic life as documented in Chapters 5, 6 and 7 and, hence, on the well-being of its residents. Ontario submits that any increase in SO_2 emissions from these sources will further impair the Ontario environment and should not be approved. In addition, other links between SO_2 deposition and damages to terrestrial ecosystems and man-made structures have been identified by researchers in several jurisdictions. Ontario has initiated a program of studies to determine the nature and extent of these effects, although results of these studies are not yet available.

Ontario also urges the EPA to vigorously enforce existing SO_2 emission standards. Our position is based on international legal principles.

No adequate evaluation has been made by EPA in these proceedings of the long range transport of pollutants to enable an assessment of the effect on Ontario of the increases sought. If EPA does not now disapprove the SIP relaxations, it should, prior to making a decision, proceed to carry out an evaluation of the cumulative impact of the revisions on Ontario and other provinces. Further, EPA should include the cumulative impact on Ontario in its evaluation of any other SIP revision it may be called on to consider. Ontario submits that this can only be accomplished by consolidation of proceedings.

BACKGROUND INFORMATION

2.1 Ontario's People and Environment

The province of Ontario is Canada's second largest province. It covers 344,092 square miles, stretching from the Great Lakes and the St. Lawrence River to the shores of Hudson's Bay. It has approximately 35% of Canada's total population; that is, 8.5 million people concentrated primarily in the urban centres of the south. The location of Ontario relative to the U.S. is illustrated in Map 2.1.

Ontario has a vital, thriving and diversified economy, much of which is dependent upon the province's natural resources. Parts of this resource base are known to be adversely affected by acid deposition. The deterioration or loss of these resources will undermine a significant proportion of Ontario's regional economies, and cause the loss of jobs and incomes.

The aquatic based tourism and outdoor recreation sectors are significant to Ontario's economy, accounting for nearly 10% of the province's economic base. These activities

Map 2.1 The Province of Ontario, shown relative to the Eastern part of the U. S. The shaded areas approximate environmentally sensitive terrain with lakes susceptible to precipitation acidity. The bulk of this terrain lies on the geological formation known as the Canadian Shield.

Code	Total No. of Lakes	Estimated Percentage Sensitive	No. of Lakes Sensitive Based on Estimate
1	40,589	50%	20,295
2	76,728	20%	15,346
3	64,133	20%	12,827
TOTALS	181,450		48,468

generate direct expenditures, conservatively estimated at $900 million in 1980. The importance of these sectors is even greater when indirect expenditures are taken into consideration, and when their net present value is calculated over the period to 2001.

In the sensitive shield area of the province (see Map 2.1), tourism and recreation account for up to 20% of some regional economies. This percentage is all the more significant due to the seasonal nature of the activities. The present and potential extent of biological damage to lakes and rivers supportive to these activities has not been fully defined, but on the basis of the latest data, indications are that 20% to 50% (36,300 to 90,750) of the lakes in these important recreational areas are sensitive to the effects of acid deposition.

The Muskoka-Haliburton area (Code 1, Map 2.1) is a prime recreation area for both Ontario residents and tourists. This area is particularly sensitive to acid deposition and currently receives a heavy acid loading from the atmosphere. This region is adjacent to the highly urbanized areas to the south. Its lakes, rivers and wilderness serve as the base of a very large tourism and recreation sector. The more remote northern areas are even more important as tourist vacation areas.

In summary, much of Ontario's economy is dependent on the province's rich natural resource base. The lakes and wilderness are a large but threatened resource, as the documented evidence in Chapter 6 on aquatic ecosystem effects indicates. The province has nearly half a million lakes, of which some 180,000 are located in the geological areas most sensitive to the effects of acid deposition. These physically sensitive areas lack the natural ability to neutralize acid deposited from the atmosphere.

Our research has developed strong linkages between acid deposition and its effects on the aquatic resource base, and between this base and the magnitude and economic value of the tourism and outdoor recreation sectors. The relationships in other areas such as terrestrial systems are less well documented but preliminary evidence suggests that acid deposition has detrimental effects on these resources which will adversely affect the provincial economy.

2.2 Sources Subject To These Proceedings

A total of twenty fossil fuel-fired thermal generating stations in six states are the subject of these proceedings. They vary considerably in terms of size, load factor, sulphur content of fuel and SIP sulphur dioxide limits. These data for each plant are summarized in Table 2.1 while Map 2.2 shows their locations.

Together, these plants account for about 19,700 megawatts (MW) of electrical power generating capacity, approximately 19% of the region's total capacity. The proportion of capacity which these plants represent varies from state to state from about 5% to 37%, as shown in Table 2.2.

Utilities throughout the United States are a large and significant contribution to total sulphur dioxide emissions. Data for 1978 and 1979 summarized in Table 2.3 indicate that utilities account for 67% to 92% of the total state emissions for the six states in which the 20 power plants are located.

The sulphur dioxide emissions from these states total approximately nine million metric tons (i.e. tonnes), or roughly 40% of the U.S. total SO_2 emissions. All utilities in these six states contribute 7.2 million metric tons to this total. This represents about 78% of the region's total sulphur dioxide emissions which is considerably higher than the national average.

TABLE 2.1

STATE	PLANT NAME	COMPANY NAME	COUNTY	GENERATION CAPACITY MW	AVE % IN SULPHUR COAL BY WEIGHT	LOAD** FACTOR %	PRESENT SIP LIMIT (LBS SO_2/MILLION BTU
ILLINOIS	Baldwin	Illinois Power Co.	Randolph	1892	2.90	66.79	4.62
INDIANA	Clifty Creek	Indiana & Kentucky Elec. Corp.	Jefferson	1304	3.95	76.31	1.20
	Tanners Creek	Indiana & Michigan Electric	Dearborn	1098	2.37	49.65	1.20
	Michigan City	Northern Indiana Public Service	La Porte	736	2.49	46.42	1.20
	Culley	Southern Indiana Gas & Electric	Warrick	414	3.34	58.94	1.20
	Bailly	Northern Indiana Public Service	Porter	615	3.09	41.92	1.27
	Stout	Indianapolis Power & Light	Marion	935	1.73	38.89	1.20
	Warrick	Southern Indiana Gas & Electric	Warrick	323	3.24	25.01	1.20
	Mitchell	Northern Indiana Public Service	Lake	529	1.00	49.19	1.20
MICHIGAN	Cobb	Consumers Power	Muskegon	510	2.58	73.24	1.00+
	Campbell	Consumers Power	Ottawa	650	2.18	61.09	1.50+
OHIO	Beckjord	Cincinnati Gas & Electric	Clermont	1416*	2.35	41.38	5.62
	Muskingum	Ohio Power Co.	Morgan	1530*	5.19	61.19	6.48
	Cardinal	Buckeye Power Inc. & Ohio Power Co.	Jefferson	1880*	1.81	64.14	4.76
	Bayshore	Toledo Edison	Lucas	655*	0.94	68.83	1.20
	Poston	Columbus & Southern Ohio	Athens	240*	3.92	34.81	3.94
	Avon Lake	Cleveland Electric Illum.Co.	Lorain	1307*	2.58	44.27	1.15***
	Eastlake	Cleveland Electric Illum.Co.	Lake	1289*	3.26	52.54	1.43***

...continued/

TABLE 2.1 (continued)

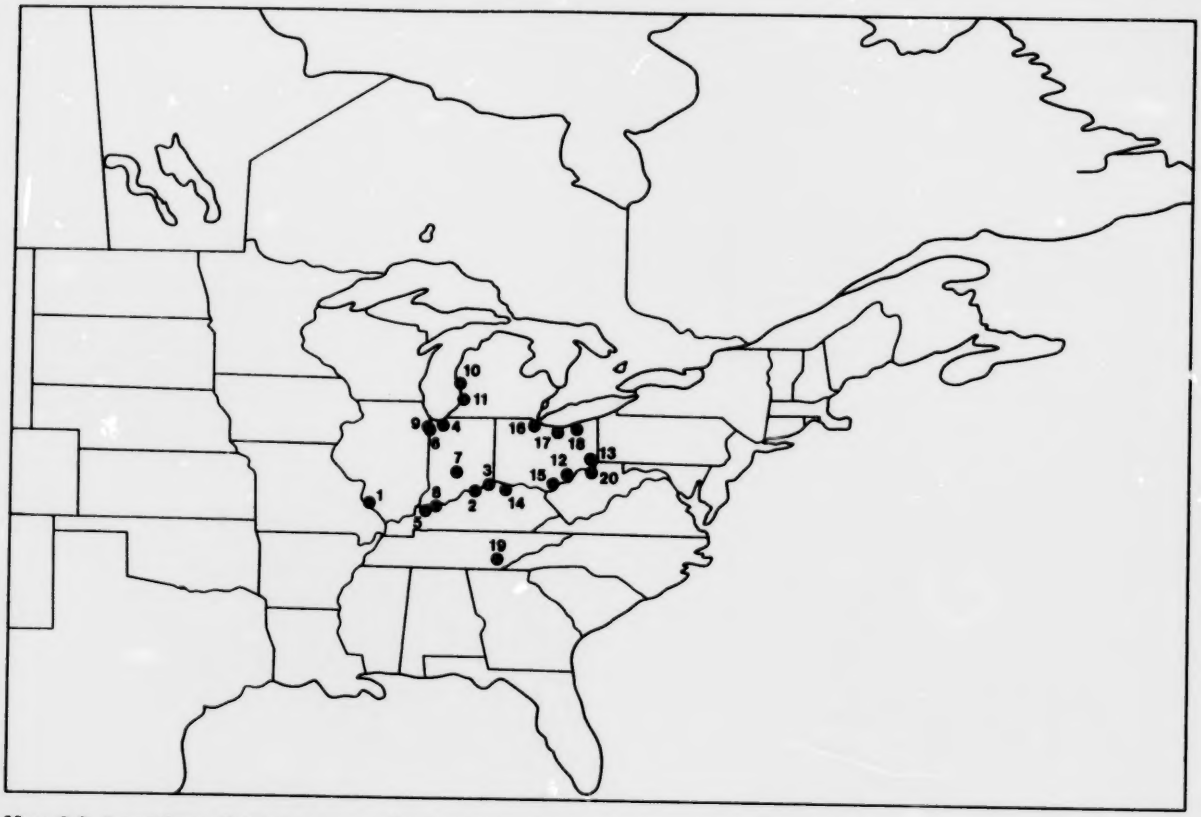
STATE	PLANT NAME	COMPANY NAME	COUNTY	GENERATION CAPACITY MW	AVE % IN SULPHUR COAL BY WEIGHT	LOAD** FACTOR %	PRESENT SIP LIMIT (LBS SO_2/MILLION BTU)
TENNESSEE	Kingston	Tennessee Valley Authority	Roane	1700	1.27	61.10	1.20
WEST VIRGINIA	Kammer	Ohio Power	Marshall	675	4.31	72.98	3.20

* c.f. EPC, Form 4 "Monthly Power Plant Report" (F.E.R.C. Form No. 4), January - December, 1979.

+ Per cent sulphur by weight

** as calculated on the basis of fuel consumption

*** We use August 27, 1976 SIP emission limits for the Avon Lake and Eastlake Plants (i.e. 1.15 and 1.43 lbs. SO_2/MBTU respectively) as the base and oppose any relaxation thereof.



Map 2.2 Location of the sources which are the subject of these proceedings.

ILLINOIS

1) Baldwin

INDIANA

2) Clifty Creek
3) Tanners Creek
4) Michigan City
5) Culley
6) Bailly
7) Stout, Elmer W.
8) Warrick
9) Mitchell, Dean H.

MICHIGAN

10) Cobb
11) Campbell

OHIO

12) Muskingum
13) Cardinal
14) Beckjord
15) Poston
16) Bayshore
17) Avon Lake
18) Eastlake

TENNESSEE

19) Kingston

WEST VIRGINIA

20) Kammer

TABLE 2.2

Thermal Power Generation

State	Total State Capacity (MW)	Map 2.2 Power Plants' Total Capacity by State (MW)	As % of State's Capacity
Illinois	23,470	1,892	8.06
Indiana	16,116	5,954	36.04
Michigan	15,606	1,160	7.4
Ohio	26,145	8,317	31.81
Tennessee	13,086	1,700	14.07
West Virginia	12,500	675	5.4
Regional Total	106,923	19,698	18.42

Source: Inventory of Power Plants, U.S. Department of Energy, April 1979.

TABLE 2.3

SO_2 EMISSION BY STATE IN 1978 and 1979*

	Total State Emissions, 1978 (thousands of metric tons)	1979, All Utility Emissions (thousands of metric tons)	Utilities As a % of State's Total
Illinois	1,585.0	1,082.5	68.3
Indiana	1,676.7	1,399.3	83.5
Michigan	1,014.1	676.3	66.7
Ohio	2,826.2	2,302.4	81.5
Tennessee	1,054.9	814.9	77.2
W. Virginia	952.1	875.3	91.9
REGIONAL TOTAL	9,109.0	7,150.7	78.5

* 1979 total State emission data not available; 1978 emissions are assumed to be sufficiently similar to 1979 for this purpose.

Many of the power generating plants which are the subject of these proceedings are located in or near large urban areas in the U.S. midwest, and the plants service their regional residents and industries. The cities of Cleveland, Gary, Cincinnati, Evansville, Toledo, Indianapolis and Grand Rapids are the centres of major manufacturing industries, primarily metals related: iron, steel, aluminum, and machinery and automobile parts. This area is a very heavily industrialized and populated region of the United States. As an example of activity in the vicinity of each power plant, Table 2.4 presents some information for those counties in which the 20 generating stations are located, and indicates the magnitude of the manufacturing sector. The data on value of industrial shipments indicates the economic importance of metals processing (iron, steel and non-ferrous metals); automobile parts manufacture (engines, bodies, carburetors); and machinery (farm, valves, pumps, and petroleum refining).

It is recognized that these industries constitute a significant part of the economic base of both this region as well as other parts of the United States. These industries are generally large consumers of electrical power, generated in part by the 20 power plants which are the subject of these proceedings.

TABLE 2.4*

STATE	PLANT	COUNTY	1977 POPULATION	URBAN CENTER (in or near)	NO. OF MANUFACTURING PLANTS IN COUNTY WITH EMPLOYEES SIZE OF: 20 TO 100	OVER 100	INDUSTRIAL SHIPMENTS $ Million	MAIN INDUSTRIES & VALUE OF SHIPMENTS $ 1979 Millions
ILLINOIS	BALDWIN	RANDOLPH	34,143	-	11	3	196	Printing (61)
INDIANA	CLIFTY CREEK	JEFFERSON	28,532	-	20	10	244	Motors & Generators (70)
	TANNERS CREEK	DEARBORN	33,622	CINCINNATI	13	7	455	Liquor (365)
	MICHIGAN CITY	LA PORTE	108,151	MICHIGAN CITY	97	45	1,116	Farm machinery (186) Compressors (68)
	CULLEY	WARRICK	38,985	EVANSVILLE	12	3	491	Primary Aluminum (447)
	BAILLY	PORTER	107,816	GARY	38	8	2,716	Steel Mills (2427)
	STOUT	MARION	774,484	INDIANAPOLIS	575	190	8,457	Engines (941) Auto Parts (327) Pharmaceuticals (595)
	WARRICK	WARRICK	33,622	EVANSVILLE	38	8	491	Aluminum (447)
	MITCHELL	LAKE	556,290	GARY	192	86	7.052	Steel Mills (2110) Petroleum (1812) Non-Ferrous Metals (413)
MICHIGAN	COBB	MUSKEGON	159,662	MUSKEGON	137	39	1,514	Autoparts (175) Non-ferrous foundries (126) Paper Mills (121)
	CAMPBELL	OTTAWA	150,459	GRAND RAPIDS	N/A**	N/A**	1,360	Autoparts (88) Metal Stamping (48)

. . .continued/

TABLE 2.4* (continued)

STATE	PLANT	COUNTY	1977 POPULATION	URBAN CENTER (in or near)	NO. OF MANUFACTURING PLANTS IN COUNTY WITH EMPLOYEES SIZE OF: 20 TO 100	OVER 100	INDUSTRIAL SHIPMENTS $ Million	MAIN INDUSTRIES & VALUE OF SHIPMENTS $ 1979 Millions
OHIO	BECKJORD	CLERMONT	119,982	CINCINNATI	32	10	185	Specialty Machinery (86)
	MUSKINGUM	MORGAN	13,935	-	6	3	126	-
	CARDINAL	JEFFERSON	95,258	-	39	18	1,072	Steel Mills (750)
	BAYSHORE	LUCAS	476,619	TOLEDO	408	130	6,463	Petroleum (1663) Cars & Parts (1557)
	POSTON	ATHENS	48,888	-	17	4	63	Hosiery (33)
	AVON LAKE	CORAIN	264,000	LORAIN-ELORIA	170	65	5,342	Motor Vehicles and Car Bodies (2407) Blast Furnaces, Steel Mills (1261)
	EASTLAKE	LAKE	211,000	CLEVELAND	227	54	1,905	Organic Chemicals (536) Trucks and Tractors (134) Ind. Process Control Inst. (118)
TENNESSEE	KINGSTON	ROANE	42,916	-	19	7	172	Games & Toys (62)
WEST VIRGINIA	KAMMER	MARSHALL	40,590	WHEELING	15	6	355	

*Information Sources: - Statistical Abstract of the U.S., 1976

- Sales and Marketing Management, April 1980, Vol 124, No. 6

**N/A means "not available"

However, the need to protect Ontario's environment and the environment of several northeastern states is urgent, as we will show in Chapters 5 through 7. A ranking of Ontario's coal-fired plants and U.S. plants in the eastern states, which are the largest emitters of SO_2 (see Table 2.5), and a ranking of the "cleanliness" of eastern U.S. and Ontario plants in terms of pounds of SO_2 emitted per million BTU (see Table 2.6) shows that several of the 20 plants in these proceedings are already in the rankings, for example, the Muskingum, Ohio plant, the Clifty Creek, Indiana plant, the Baldwin, Illinois plant, the Eastlake, Ohio plant, the Kammer, West Virginia plant, the Beckjord, Ohio plant and the Avon Lake, Ohio plant. Furthermore, if the proposed relaxations occur, several of the above plants would then move up in the rankings and some plants not currently in the emitted SO_2 tonnage rankings would then be included, for example, the Tanners Creek, Indiana plant, the Kingston, Tennessee plant, the Warrick, Indiana plant, and the Michigan City, Indiana plant.

While these examples illustrate the larger increases proposed, it is the position of the Ontario Government that it opposes the relaxation of any existing laws, standards, or regulations. The Ontario Government also opposes any failure to enforce existing laws, standards, or regulations which result in increased SO_2 emissions. All emissions of SO_2 produce a cumulative and damaging effect to the environment encompassed by the regional airshed which Ontario, the midwest, and the northeastern states all share.

TABLE 2.5

TOP 50 COAL-FIRED POWER PLANTS RANKED ACCORDING TO TOTAL SO_2 EMISSION IN 1979

RANK	PLANT	STATE	COUNTRY	ESTIMATED SO_2 EMISSION THOUSANDS OF METRIC TONS/YEAR	
1	PARADISE	KENTUCKY	U.S.A.	372.5	
2	MUSKINGUM	OHIO	U.S.A.	340.2	
3	GAVIN	OHIO	U.S.A.	339.5	
4	CUMBERLAND	TENNESSEE	U.S.A.	289.7	
5	MONROE	MICHIGAN	U.S.A.	264.9	
6	CLIFTY CREEK	INDIANA	U.S.A.	263.7	
7	GIBSON	INDIANA	U.S.A.	261.1	
8	BALDWIN	ILLINOIS	U.S.A.	257.9	
9	LABADIE	MISSOURI	U.S.A.	224.0	
10	KYGER CREEK	OHIO	U.S.A.	205.5	
11	BOWEN	GEORGIA	U.S.A.	202.6	
12	CONESVILLE	OHIO	U.S.A.	186.8	
13	MITCHELL	WEST VIRGINIA	U.S.A.	186.2	
14	HATFIELDS	PENNSYLVANIA	U.S.A.	167.3	
15	NEW MADRID	MISSOURI	U.S.A.	164.0	
16	SAMMIS	OHIO	U.S.A.	160.7	
17	LAMBTON	ONTARIO	CANADA	160.2	
18	WANSLEY	GEORGIA	U.S.A.	159.7	
19	HOMER CITY	PENNSYLVANIA	U.S.A.	159.1	
20	JOHNSONVILLE	TENNESSEE	U.S.A.	157.9	
21	NANTICOKE	ONTARIO	CANADA	155.0	
22	GASTON EC	ALABAMA	U.S.A.	154.8	
23	MONTROSE	MISSOURI	U.S.A.	147.1	
24	HARRISON	WEST VIRGINIA	U.S.A.	142.8	
25	BRUNNER ISL.	PENNSYLVANIA	U.S.A.	142.0	– TANNERS CREEK
26	COFFEEN	ILLINOIS	U.S.A.	141.8	
27	CARDINAL	OHIO	U.S.A.	140.8	– KINGSTON
28	EASTLAKE	OHIO	U.S.A.	137.4	
29	KAMMER	WEST VIRGINIA	U.S.A.	136.8	
30	KINCAID	ILLINOIS	U.S.A.	136.3	
31	KEYSTONE	PENNSYLVANIA	U.S.A.	127.2	
32	STUART J.M.	OHIO	U.S.A.	125.6	
33	CAYUGA	INDIANA	U.S.A.	121.7	– WARRICK
34	SHAWNEE	KENTUCKY	U.S.A.	111.0	
35	GALLATIN	TENNESSEE	U.S.A.	110.6	
36	MONTOUR	PENNSYLVANIA	U.S.A.	109.4	
37	BIG BEND	FLORIDA	U.S.A.	109.2	
38	CONEMAUGH	PENNSYLVANIA	U.S.A.	108.9	
39	WIDOWS CREEK	ALABAMA	U.S.A.	106.0	
40	AMOS	WEST VIRGINIA	U.S.A.	105.2	
41	THOMAS HILL	MISSOURI	U.S.A.	104.9	
42	JOPPA STEAM	ILLINOIS	U.S.A.	104.9	
43	MT. STORM	WEST VIRGINIA	U.S.A.	102.5	
44	PETERSBURG	INDIANA	U.S.A.	100.7	– MICHIGAN CITY
45	BECKJORD	OHIO	U.S.A.	99.7	

. . .continued/

TABLE 2.5 (continued)

TOP 50 COAL-FIRED POWER PLANTS RANKED ACCORDING TO TOTAL SO_2 EMISSION IN 1979

RANK	PLANT	STATE	COUNTRY	ESTIMATED SO_2 EMISSION THOUSANDS OF METRIC TONS/YEAR
46	AVON LAKE	OHIO	U.S.A.	98.0
47	FORT MARTIN	WEST VIRGINIA	U.S.A.	94.6
48	MIAMI FORT	OHIO	U.S.A.	94.2
49	LAKEVIEW	ONTARIO	CANADA	91.4
50	YATES	GEORGIA	U.S.A.	88.8

POWER PLANTS WERE CONSIDERED FROM ONTARIO AND 32 EASTERN U.S. STATES. THE STATISTICS ARE FROM ONTARIO HYDRO AND THE U.S. DEPARTMENT OF ENERGY; THE ANALYSIS WAS PERFORMED BY THE ONTARIO MINISTRY OF ENVIRONMENT, AIR RESOURCES BRANCH.

TABLE 2.6

TOP 50 COAL-FIRED POWER PLANTS RANKED ACCORDING TO SO_2 EMISSION "CLEANLINESS" IN 1979

RANK	PLANT	STATE	COUNTRY	ESTIMATED LBS. SO_2/ MILLION BTU	MAXIMUM ACCORDING TO STATE REGULATION (LBS. SO_2/ MILLION BTU)
1	MONTROSE	MISSOURI	U.S.A.	10.86	16.00
2	MUSKINGUM	OHIO	U.S.A.	8.72	6.48
3	THOMAS HILL	MISSOURI	U.S.A.	7.85	16.00
4	KAMMER	WEST VIRGINIA	U.S.A.	7.24	3.20
5	PARADISE	KENTUCKY	U.S.A.	7.22	5.20
6	KINCAID	ILLINOIS	U.S.A.	6.94	6.00
7	CLIFTY CREEK	INDIANA	U.S.A.	6.85	1.20
8	COFFEEN	ILLINOIS	U.S.A.	6.78	6.00
9	KYGER CREEK	OHIO	U.S.A.	6.50	8.20
10	NEW MADRID	MISSOURI	U.S.A.	5.75	16.00
11	CUMBERLAND	TENNESSEE	U.S.A.	5.71	5.00
12	MITCHELL	WEST VIRGINIA	U.S.A.	5.39	3.12
13	JOHNSONVILLE	TENNESSEE	U.S.A.	5.15	1.20
14	EASTLAKE	OHIO	U.S.A.	5.14	1.43
15	CONESVILLE	OHIO	U.S.A.	5.11	5.66
16	GIBSON	INDIANA	U.S.A.	5.09	16.00
17	BALDWIN	ILLINOIS	U.S.A.	5.08	1.80
18	GAVIN	OHIO	U.S.A.	4.92	9.50
19	CAYUGA	INDIANA	U.S.A.	4.41	16.00
20	GALLATIN	TENNESSEE	U.S.A.	4.38	5.00
21	BIG BEND	FLORIDA	U.S.A.	4.26	1.50
22	AVON LAKE	OHIO	U.S.A.	4.07	1.15
23	BECKJORD	OHIO	U.S.A.	4.01	2.02
24	LABADIE	MISSOURI	U.S.A.	3.99	16.00
25	HARRISON	WEST VIRGINIA	U.S.A.	3.93	4.11
26	HATFIELDS	PENNSYLVANIA	U.S.A.	3.86	4.00
27	MONROE	MICHIGAN	U.S.A.	3.77	5.60
28	CONEMAUGH	PENNSYLVANIA	U.S.A.	3.77	4.00
29	SAMMIS	OHIO	U.S.A.	3.70	2.91
30	LAMBTON	ONTARIO	CANADA	3.55	-
31	PETERSBURGH	INDIANA	U.S.A.	3.44	16.00
32	JOPPA STEAM	ILLINOIS	U.S.A.	3.41	6.00
33	BRUNNER ISL.	PENNSYLVANIA	U.S.A.	3.38	4.00
34	SHAWNEE	KENTUCKY	U.S.A.	3.37	1.20
35	MIAMI FORT	OHIO	U.S.A.	3.34	3.30
36	LAKEVIEW	ONTARIO	CANADA	3.33	-
37	NANTICOKE	ONTARIO	CANADA	3.29	-
38	WANSLEY	GEORGIA	U.S.A.	3.25	N/A
39	BOWEN	GEORGIA	U.S.A.	3.10	N/A
40	MT STORM	WEST VIRGINIA	U.S.A.	3.09	2.90

. . .continued/

TABLE 2.6 (continued)

TOP 50 COAL-FIRED POWER PLANTS RANKED ACCORDING TO SO_2 EMISSION "CLEANLINESS" IN 1979

RANK	PLANT	STATE	COUNTRY	ESTIMATED LBS. SO_2/ MILLION BTU	MAXIMUM ACCORDING TO STATE REGULATION (LBS. SO_2/ MILLION BTU)
41	HOMER CITY	PENNSYLVANIA	U.S.A.	3.09	4.00
42	CARDINAL	OHIO	U.S.A.	3.00	4.76
43	GASTON EC	ALABAMA	U.S.A.	2.95	1.20
44	YATES	GEORGIA	U.S.A.	2.93	N/A
45	WIDOWS CREEK	ALABAMA	U.S.A.	2.88	1.20
46	FORT MARTIN	WEST VIRGINIA	U.S.A.	2.83	3.20
47	KEYSTONE	PENNSYLVANIA	U.S.A.	2.82	4.00
48	MONTOUR	PENNSYLVANIA	U.S.A.	2.51	4.00
49	STUART J.M.	OHIO	U.S.A.	2.04	3.16
50	AMOS	WEST VIRGINIA	U.S.A.	1.30	2.01

POWER PLANTS WERE CONSIDERED FROM ONTARIO AND 32 EASTERN U.S. STATES. THE STATISTICS ARE FROM ONTARIO HYDRO AND THE U.S. DEPARTMENT OF ENERGY; THE ANALYSIS WAS PERFORMED BY THE ONTARIO MINISTRY OF ENVIRONMENT, AIR RESOURCES BRANCH.

ONTARIO SHOULD BE HEARD IN THESE PROCEEDINGS

As will be evident from the information set out in this submission, Ontario will be adversely affected by any decision of the Administrator which has the effect of increasing allowable SO_2 emissions. Ontario bases its claim to be heard on:

(a) The Administrative Procedure Act,

(b) U.S. judicial decisions,

(c) Section 115 of the Clean Air Act and,

(d) International law.

The petitions by New York were submitted pursuant to S. 126 of the Clean Air Act. Ontario does not rely on S. 126 as the right to petition conferred under that provision is limited to "any State or political subdivision" and does not include Ontario.

3.1 The Administrative Procedure Act (A.P.A.)

S. 4(d) of the Administrative Procedure Act (A.P.A.) confers a right on an interested person to petition for the issuance, amendment or repeal of a rule. ((5 U.S.C.S.553(e)).

Ontario complies with the requirements of the A.P.A. by submitting the instant submission and comments. Further, 5 U.S.C.S.555(b) provides, in part,

> *"So far as the orderly conduct of public business permits, an interested person may appear before an agency or its responsible employees for the presentation, adjustment, or determination of an issue, request, or controversy in a proceeding, whether interlocutory, summary, or otherwise, or in connection with an agency function."*

As Ontario will be adversely affected by any decision which involves a relaxation of a SIP with respect to SO_2 emissions, we submit that Ontario should, therefore, be heard in these proceedings.

It has been held that approval of a SIP without permitting participation by interested persons was a violation of the A.P.A.

Buckeye Power Inc. v E.P.A., 481 F2d 162 (6th Cir. 1973)

In the Buckeye Power case three power companies protested that the Ohio and Kentucky SIPs were approved by the Administrator without permitting them to participate by notice and comment. Because the Administrator built no record, took no comments from interested parties and permitted no public participation in approving these plans, he violated S.553 of the A.P.A. Thereupon the court vacated the defective approval and

remanded the case to the Agency for compliance. Since the requirements for approval of a SIP revision under S.110(a)(3) of the Clean Air Act are the same as for approval of an initial plan ((S110(a)(2)), the Administrator must allow Ontario to participate in these proceedings.

3.2 Decisions of U.S. Courts

Further support for Ontario's claim to be heard in these proceedings may be found in opinions rendered by American federal appellate courts which permitted access by foreign parties to proceedings before U.S. administrative tribunals.

> Cia Mexicana de Gas, S.A. v. Federal Power Commission (Reynosa Pipe Line Co., Intervener), State of Texas et al. v. Federal Power Commission, 167 F.2d 804 (5th Cir. 1948)
>
> Juarez Gas Company, S.A., Petitioner v. Federal Power Commission, Respondent, Southern Union Gas Company, Del Norte Natural Gas Company, Interveners, 375 F.2d 595 (D.C. Cir. 1967)

Both of these cases involve petitions by Mexican corporations seeking to review orders of the U.S. Federal Power Commission. The Mexican companies asserted that the granting of a certificate authorizing the export of natural gas to Mexico affected them as a competitor of the company to whom the certificate was granted. In each case, the Circuit Court of Appeals found that the Mexican companies were "aggrieved parties" within the meaning of the Natural

Gas Act and proceeded to review the orders of the Federal Power Commission. The courts approached the issue on the basis of whether the petitioner was "aggrieved" and thus entitled to participate in the proceedings. The test was whether the Mexican company might be adversely affected by the administrative procedure in question.

Additional support for Ontario's position may be found in the judgement of the United States Court of Appeals in The Wilderness Society et al. (David Anderson and The Canadian Wildlife Federation), Appellants, v. Rogers C.B. Morton, Secretary of the Interior et al.[1] The case concerned the application of a Canadian citizen and a Canadian environmental organization to intervene in litigation aimed at testing whether the Secretary of the Interior had complied with the procedures of the National Environmental Policy Act prior to deciding whether to issue a permit for the trans-Alaska pipeline. The court found that the position of the Canadian environmental organization was sufficiently antagonistic to the positions of U.S. environmental organizations, which were also parties to the litigation, to require the granting of the application for leave to intervene. The word antagonistic was used in the sense of division of opinion concerning possible alternatives. In this case, that division of opinion may lead to the interests of the Province of Ontario going unrepresented unless it is permitted to participate.

3.3 Proceedings Under Section 115, Clean Air Act

Ontario should also be heard in respect of the proceedings under S.115 of the Clean Air Act. The matter under S.115 should in turn be regarded as inseparable from the instant proceedings. It makes little sense to approve SO_2 relaxations now which may conflict with the result of a S.115 proceeding already initiated. The section has been activated in that the two conditions, which must be met before the Administrator is required to give notification to the States where emissions originate, have been complied with. On January 16, 1981, the Administrator said:

> *"In summary, my conclusions are adequate to warrant the initiation of Section 115. Under this provision, formal notification is given to a Governor that his State must identify and propose pollution control measures to address the international problem, and provide opportunity for public hearing on these plans. I have instructed my staff to examine this issue and recommend which States should be notified."*[2]

The activation of S.115 places the Administrator under a legal obligation to give formal notification to the Governors of the States in which emissions originate. Information made available by Ontario in this submission will assist in this determination. Ontario seeks to participate in these proceedings both as a Province being severely affected by acid precipitation and as being in possession of information (regarding effects in Ontario and the causes thereof) which is needed by the Administrator to carry out the obligation which is placed upon him by S.115 of the Clean Air Act.

These proceedings should be combined as otherwise relaxations granted now may be totally inconsistent with results of the ongoing S.115 proceedings and may compromise those proceedings.

3.4 Access Under International Law

Ontario also submits that general principles of international law require it to be heard in this proceeding. The principle of international law relied on below, that every State has a duty of care to prevent its nationals from committing air pollution injury against other States, should be implemented by the recognition of procedural requirements. Among these should be recognition of the principle of the right of access by foreign parties, including both government agencies and individuals, to administrative proceedings which may directly impact on them. Only in this way can the principles of international law discussed more fully below be implemented. Consistent with this, both the States of California and Alaska were allowed to intervene before the National Energy Board of Canada in hearings respecting a natural gas pipeline (Hearing RH-2-79). Such access is implied in accords such as the Great Lakes Water Quality Agreement of 1978 (Articles II and III).

3.5 Stage of the Proceedings*

Ontario should be hear notwithstanding the advanced stage of the proceedings. Ontario learned of these proceedings only after filing of petitions by New York. Only then in late January, 1981 did Ontario become aware of the large number of emission limit revisions under consideration. Yet under the Memorandum of Intent between the U.S. and Canada, signed on August 5, 1980, both governments undertook to "continue and expand their longstanding practice of advance notification and consultation on proposed actions involving a significant risk or potential risk of causing or increasing transboundary air pollution."

Ontario is not aware of the results of any study by E.P.A. or any other U.S. government agency which evaluated whether the cumulative effect of proposed SIP revisions would increase transboundary air pollution nor of any notice given in respect thereof.

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*This subsection is redundant with respect to Docket No. 5A-79-1 in view of EPA reopening the comment period.

REFERENCES - CHAPTER 3

1. 463 F. 2d (1972).

2. "ENVIRONMENTAL NEWS"
   January 16, 1981.

LAW

4.1 Rights Conferred by Accords

On August 5, 1980 the Government of Canada and the Government of the United States of America entered into a Memorandum of Intent concerning transboundary air pollution. In this document the parties declared their intention

> *"to develop a bilateral agreement which will reflect and further the development of effective domestic control programs and other measures to combat transboundary air pollution".*

Both parties undertook to take certain interim actions pending conclusion of such an agreement. These interim actions included the following undertaking with respect to control measures.

> *"To combat transboundary air pollution both Governments shall:*
>
> *(a) develop domestic air pollution control policies and strategies, and as necessary and appropriate, seek legislative or other support to give effect to them;*
>
> *(b) Promote vigorous enforcement of existing laws and regulations as they require limitation of emissions from new, substantially modified and existing facilities in a way which is responsive to the problems of transboundary air pollution; and*

(c) *share information and consult on actions being taken pursuant to (a) and (b) above".*

It is the position of Ontario that the Administrator must take account of the above undertakings and should make his decision with respect to proposed SIP revisions in a manner consistent with such undertakings. The Administrator signed the Memorandum of Intent and is obviously the person intended to implement those aspects which relate to his functions. Ontario submits that the development of "domestic air pollution control policies and strategies" requires the Administrator to take account of the impact on Ontario and other Provinces of emissions originating in States seeking SIP revisions. Such control policies and strategies must include consideration of the cumulative effect on Ontario and other Provinces of all pending SIP revisions. The information set out in this submission should lead the Administrator to conclude that any increase in SO_2 emissions from sources will further impair the Ontario environment and should not be permitted.

Ontario further bases its submission on the undertaking set out above

> *"to promote vigorous enforcement of existing laws and regulations as they require limitation of emissions from... existing facilities in a way which is responsive to the problems of transboundary air pollution".*

This requires that all necessary enforcement action be taken to restrict existing facilities within legally permissible standards. Many sources now seeking SIP relaxations have not been in compliance with the allowable limits.[1]

Ontario further relies on the undertaking in the above Memorandum to continue the practice of

> *"advance notification and consultation on proposed actions involving a significant risk or potential risk of causing or increasing transboundary air pollution".*

Ontario submits that the above provisions require E.P.A. to evaluate the cumulative effects of all SIP relaxations on Ontario and other provinces, to give proper notification of the results thereof and to consult thereon.

Indeed existing standards should be enforced "in a way which is responsive to the problems of transboundary air pollution" and consultation should occur in order to assure such enforcement.

On 22 November 1978 the U.S. and Canada signed the Great Lakes Water Quality Agreement of 1978 which provides that the Great Lakes system (of which the affected areas of Ontario are a part) shall be free from substances that will adversely affect aquatic life or are harmful to human, animal or aquatic life (Article III). The Agreement announced the policy of the two nations to develop and implement co-

ordinated planning and management practices by the federal, state, provincial and local governments (Article II).

4.2 Duty of State to protect other States from injurious acts

The principles of international law governing a transboundary pollution situation are set out in the Report of the Arbitral Tribunal in the Trail Smelter Arbitration.[2]

In that case a smelter located in Trail, B.C. was emitting sulphur dioxide which caused damage to areas in the State of Washington. In order to resolve the dispute over liability and damages, the matter was referred to an Arbitral Tribunal established pursuant to an international convention. The decision of the tribunal establishes the principles governing transboundary pollution.

The initial dispute in Trail Smelter concerned a private nuisance claim against a corporation in Canada by residents of the State of Washington. Although the dispute did not directly concern the two governments, they agreed to submit it to arbitration. It was, therefore, accepted that Canada would be responsible for any damages caused by the corporation and that the U.S. was the proper claimant to represent claims by its citizens.

The decision of the Arbitral Tribunal in Trail Smelter establishes the following fundamental principle:

> *"A State owes at all times a duty to protect other States against injurious acts by individuals from within its jurisdiction...International decisions, in various matters,...are based on the same general principle,[3]..."*

In the language cited above, the decision established that the State is responsible to another State not only for the injurious acts and emissions of its government but also vicariously for the injurious acts of its citizens.

In the decision of the Arbitral Tribunal, the principle was also stated in the following language:

> *"...under the principles of international law, as well as the law of the United States, no state has the right to use or permit the use of its territory in such manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence".*[4]

A reading of the decision in Trail Smelter makes it clear that the conclusions reached were based on decisions of the Supreme Court of the United States. This point was noted by the Tribunal as follows:

> *"the law followed in the U.S. in dealing with quasi-sovereign rights of the States of the Union, in the matter of air pollution, whilst more definite, is in conformity with general rules of international law".*[5]

The above authority indicates that a State should act in such a manner as not to permit the use of its territory so as to cause injury by pollution to the territory of another. When the context is not compensation being sought, but rather a proposed administrative decision which could lead to increased emissions, we submit that the onus should be on anyone justifying such increases or proposing to approve them to establish that there will be no injury by pollution to the territory of another country.

In any event, Ontario says that the injury it now suffers from acid deposition from U.S. sources and the cumulative effect of the increases proposed in the SIP relaxations now pending make it clear that the case is of serious consequence. Ontario further submits that the information set out in this submission establishes such injury on clear and convincing evidence.

Both U.S. and Canada have adopted Principle 21 of the 1972 Stockholm Declaration on the Human Environment, which says:

> *"...States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction...".*

Further, both the U.S. and Canada have signed the United Nations convention of November 13, 1979 on Long Range Transboundary Air Pollution. In this the parties recognized,

> *"the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."*

Ontario says, therefore, that the Administrator should act in such a manner as to cause the United States to comply with the principles of international law stated above. To approach the question of SIP revisions in a piece-meal manner without considering serious consequences to Ontario and other Provinces would be to proceed blindly and contrary to principles of law. In the present case, the Administrator should consider the cumulative impacts of all sources involved in proposed SIP revisions and should reject any revisions which result in increased SO_2 emissions impacting on Ontario or other Provinces.

4.3 S.115 Clean Air Act, Basis of Substantive Law

In addition to the August 1980 Memorandum of Intent and General Principles of International Law, Ontario submits that these proceedings are, or should be, governed by S. 115 of the Clean Air Act. The section is discussed above with regard to access by Ontario to these proceedings. S. 115a reads as follows,

> *"Whenever the Administrator, upon receipt of reports, surveys or studies from any duly constituted international agency has reason to believe that any air pollutant or pollutants emitted in the United States cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare in a foreign country or whenever the Secretary of State requests him to do so with respect to such pollution which the Secretary of State alleges is of such a nature the Administrator shall give formal notification thereof to the Governor of the State in which such emissions originate."*

On January 16, 1981 the Administrator of the Environmental Protection Agency announced that he had reached conclusions adequate to warrant the initiation of S. 115[6]. The reasoning of the Administrator in reaching these conclusions has been set out in correspondence.[7] Relying on a recent report of the International Joint Commission, the Administrator made the following statement:

> *"The International Joint Commission which is a duly constituted international agency under Section 115, has recently transmitted a report which addresses the issue of acid deposition. My review of the October 1980 Seventh Annual Report on Great Lakes Water Quality of the International Joint Commission (IJC) leads me to conclude that the IJC has found acid deposition results in significant harm in both the U.S. and Canada and that emission sources in both the U.S. and Canada contribute to the problem through the long-range transport of air pollution. The IJC Report states that '(a)cidic precipitation is one widely known and serious example of a problem associated with the long-range transport of airborne pollutants.' (Report at 49). The Report states that '(v)irtually all of eastern Canada and portions of the northeastern United States experience rains with acidity equal to or exceeding that which can adversely affect susceptible ecosystems. All parts of the*

Great Lakes watershed are now receiving precipitation containing 5 to 40 times more acid than would occur in the absence of atmospheric emissions. Many inland lake ecosystems in the most susceptible parts of the Basin may be irreversibly harmed within 10-15 years' (Report at 50). The Report also notes that '(a) substantial portion of the Great Lakes drainage basin is potentially susceptible to acidic precipitation, based on its bedrock geology. The Sudbury, Muskoka and Haliburton areas of Ontario and the Adirondacks of northern New York are among the most heavily impacted areas in the world because their geology offers little buffering capacity to their inland lakes. Some lakes in the Haliburton-Muskoka area have lost 40-75 percent of their acid neutralizing ability in a decade or less. These areas are now being subjected to precipitation which is twice as acidic as that which caused losses of major fish stocks in thousands of Scandinavian lakes.' (Report at 50)."

The Administrator also concluded that new Canadian legislation provides Canada with ample authority to give the U.S. essentially the same rights as S. 115 while emphasizing that this aspect would be subject to ongoing evaluation as to Canada's interpretation and implementation of its legislation.

Ontario submits that all of the sources involved in these proceedings significantly contribute to the air pollution problem identified pursuant to S. 115. It is clear from the wording of S. 115b that the S. 115 process leads to SIP revisions

"adequate to prevent or eliminate the endangerment referred to in sub-section (a)."

As the information set out in this submission establishes that Ontario is already subject to levels of acidic precipitation which seriously impair the environment and affect the welfare of its residents, any increased emissions would be inconsistent with the obligations of the Administrator under S. 115. Those proceedings must lead to substantial reductions to fulfill their statutory objective. Therefore, any increases in emissions in the instant proceedings would compromise the proceedings under S. 115. Ontario submits that in order to carry out the obligation imposed on her, the Administrator must first evaluate in a systematic way and on the basis of the best information available the impact of the proposed increases on Ontario and other parts of Canada.

REFERENCES - CHAPTER 4

1. Table 7.1

2. Trail Smelter Arbitration, American Journal of International Law (1941) 684.

3. Ibid, 713.

4. Ibid, 716.

5. Ibid, 713.

6. Environmental News, January 16, 1981.

7. Letter D. COSTLE to SENATOR G. MITCHELL, January 13, 1981.

5.

ESTABLISHING THE CAUSE OF ACID DEPOSITION IN ONTARIO

5.1 Introduction

This chapter reviews the causes of acid deposition in Ontario and shows how a significant amount of this deposition (in both the dry and wet forms)[1] comes from the states mentioned in this submission. The review draws from many studies of acid deposition and long range transport which are currently in the technical literature, and each section in the chapter discusses one step in establishing how the emission sources of SO_2 are causing a part of this deposition. Subsequent chapters will discuss the effects of this deposition and the significance of the proposed SIP relaxations for SO_2 emissions on Ontario's environment. The two final chapters will show how Ontario is pursuing a policy of drastically reducing its own SO_2 emissions, as well as requesting similar levels of reductions from neighbouring jurisdictions.

It is important to emphasize that a reduction of SO_2 emissions is needed on an eastern North American basis to eliminate the damage caused by acid deposition. In decades past, environmental protection of air quality was approached on a "local" rationale -- that is, airsheds were thought of as small areas surrounding urban zones or rural industrial activity. However, as this chapter will demonstrate, the

protection of the environment from acid deposition (as well as from other problems such as oxidants) requires a change in thinking patterns. An "airshed" can no longer be considered as an entity having localized boundaries and subject to localized styles of management or regulation. The "airshed" is common to many states and provinces of the U.S. and Canada, and pollution control to protect the environment and health of people in that airshed must be a shared responsibility of all parties in that airshed. Chapter 8 of this submission will clearly illustrate why action on the part of one jurisdiction such as Ontario to lessen SO_2 emissions is fruitless unless its neighbours -- the midwestern and eastern states of the U.S. -- also take action.

The Government of Ontario knows that the EPA is undertaking studies of air pollution problems in regional, multi-state airsheds.[2-5] This is encouraging, but inadequate from our point of view. A glance at a map of Ontario (see Map 2.1) shows that the most environmentally sensitive part of Ontario is literally wedged between the middle of a highly industrialized group of states. Our part of the regional airshed is intimately related to the U.S. portion of the same airshed; therefore, Ontario's environment must be studied, assessed, and protected in close concert with the U.S.

Ecological damage resulting from the intimacy of the airshed relationship is not limited to acid deposition. Concern has been noted over the past two decades about

oxidant damage in Ontario[6,7] due to sources in distant areas, and a recent IJC report[8] highlights growing concern that the atmospheric deposition of organic compounds such as PCB's and pesticides into the Great Lakes is a major source of contamination of these water bodies. The IJC further states that much of the deposition is likely due to distant sources.

Ontario submits that the existence of these other regional air quality problems is further compelling evidence that jurisdictions must consider pollution effects and related control strategies on the large-scale regional airshed basis.

5.2 Description of Weather Systems Affecting Ontario

Ontario is a large province, and air masses move across the various parts of the province from different directions. Because the acid deposition problem is documented to be greatest in the Southern part of Ontario (that is, the area approximately covered by region 1 of Map 2.1), this chapter will focus on weather systems moving over this part of the province. This section discusses the evolution of systems bringing in both precipitating and non-precipitating air masses, as these systems contribute to wet and dry acid deposition respectively.

Wind directions into and across Ontario have a westerly prevalence with a higher percentage frequency north of west in the winter and a higher percentage frequency south of west in the summer. As a low pressure area bringing precipitation moves in, it is preceded by a southerly circulation of warm humid air. It is followed by a cold frontal passage and a northerly flow of relatively dry air. The high pressure area which follows the low will return the winds to a south and southwest direction. While dry air may be from any direction, air masses leading to precipitation most frequently originate from the south.

5.3 Dry Acid Deposition and the Weather

5.3.1 Background

Weather conditions that control air movements play an important role in the long distance transport of pollutants that contribute to the dry and wet deposition of acidic materials.

Whenever a pollutant is released into the lower atmosphere, it may either (a) be deposited on the surface near the source (i.e. within about 50 km) through the actions of gravity, turbulent diffusion, rain, or snow, or (b) undergo chemical transformation and be deposited locally or (c) it may be transported in either its original or transformed state many hundreds or thousands of kilometers by the wind before falling to the earth. Recent research[9-11] has done much to enhance the understanding of how some of these

pollutants react as they are transported, but the exact mechanisms are still not completely understood. Nevertheless, the general features are well enough delineated to link the precursors of acid deposition with the deposition itself.[12-14]

In the case of dry acid deposition, high ground level concentrations of sulphates and/or nitrates are a good indicator that the dry acid deposition process is likely.[15] In what follows, conditions giving rise to high levels of acid deposition and the frequency of these deposition episodes will be discussed.

5.3.2 Evidence of Contributions from Southerly and Northerly Sources

In the past decade, there have been numerous studies which have shown that pollutants such as sulphur dioxide, sulphates, ozone, and nitrates are transported over hundreds or even thousands of kilometers by the winds before they are dry-deposited to the earth's surface. A number of these studies[16-24] are concerned with the long-range transport of pollutants into Southern Ontario from the highly industrialized regions of the United States south of the Great Lakes.

One of the first studies that indicated the long-range transport of pollutants into Ontario was undertaken in response to ozone damage to tobacco crops north of Lake Erie.[6] This study concluded that the flecking of tobacco plants occurred when the air masses containing high ozone

concentrations in Ontario had been over the industrial areas of the United States south of Lake Erie six to twelve hours earlier.

More recent studies[16,19] have shown that summer ozone concentrations are highest in Southern Ontario during a flow of warm air from the south which occurs with the passage of the northwest sector of a high pressure area. The number of days with high levels of ozone varies considerably from year to year, but the frequency is significant. For example, in 1978 there were 43 days of elevated levels while in 1979 there were 14. The ozone was often associated with high levels of sulphates. Back trajectories of the air parcels show that air arriving in Southern Ontario with high ozone and sulphate concentrations originated south of the Great Lakes. In contrast, air of northerly origin has been demonstrated to have much lower pollutant concentrations. U.S. studies have shown that high pollutant levels in the northeastern United States were associated with air flows from the Ohio Valley and comparably clean air was associated with a northerly circulation from Canada.[25-29]

5.3.3 Specific Examples of Pollution from the South

The long range transport of acid-deposition-related pollutants over eastern North America is often evident from aircraft. During sunny days, haze in the lowest few thousand foot layer can be seen extending for hundreds or thousands

of kilometers covering both urban and rural areas. Satellite photographs of eastern North America have shown large hazy air masses present in cloud-free regions.[30] Further investigations have revealed that this air is characterized near the surface by low visibility and high concentrations of sulphate particles and ozone. By analyzing a series of these photographs, the path history of the "smog area" can be reconstructed.

The history of one such event (August 16-28, 1976) showed the "smog area" south of the Lower Great Lakes and spreading over the entire Lower Great Lakes region by August 22nd. A weak cold front pushed the "smog area" southward on the 23rd, but it again moved northward across Southern Ontario on the 26th. Particulate sulphate concentrations exceeded 40 micrograms per cubic meter ($\mu g/m^3$) at several Ontario sites during this period. In addition, the origin of the sulphate-laden air, reported in an area extending from Windsor to Quebec City, was demonstrated to be the Ohio, Pennsylvania, and West Virginia regions.[19] The concentrations of sulphates reported at ground level over Ontario, Quebec and the northeastern United States on August 16, 22 and 28 are shown in Figures 5.1, 5.2 and 5.3. These figures indicate that the measured levels of sulphates caused the reduction in visibility that was evident in the satellite photographs.

A second example shows that sulphates may occur in the absence of ozone, in the winter season. One such episode occurred in February 1979. A prolonged cold spell in Southern Ontario was broken with the onset of southerly winds that brought warm air into and across the province,[24] following the passage of a slow eastward moving high pressure area from southwest of the Great Lakes to the Atlantic Seaboard. As the winds shifted to the southerly direction, sulphur dioxide concentrations began to rise on February 19 in the southwest part of the province. By mid-day of February 20, they had spread to Ontario's eastern areas. The rise in sulphur dioxide concentrations was most pronounced at rural monitoring sites where sulphur dioxide concentrations are normally near zero. Particulate sulphate concentrations were also unusually high, accounting for around 30% of the suspended particulate matter at some sites. The maximum sulphate concentration during this period was 67.5 $\mu g/m^3$. Trajectory analyses indicated that the high concentrations of these sulphur compounds were associated with air movement from south of the Great Lakes. The Ontario Air Pollution Index,[31] which is based on sulphur dioxide and suspended particulate concentrations and is designed to protect the health of the Ontario public, rose above the Advisory Level in three Ontario cities during this time period. As a result, Ontario industries were asked by the Ontario Ministry of the Environment to curtail emissions in compliance with Ontario's Environmental Protection Act. The subsequent investigation[24] showed that approximately 50% of the pollutants originated in the United States.

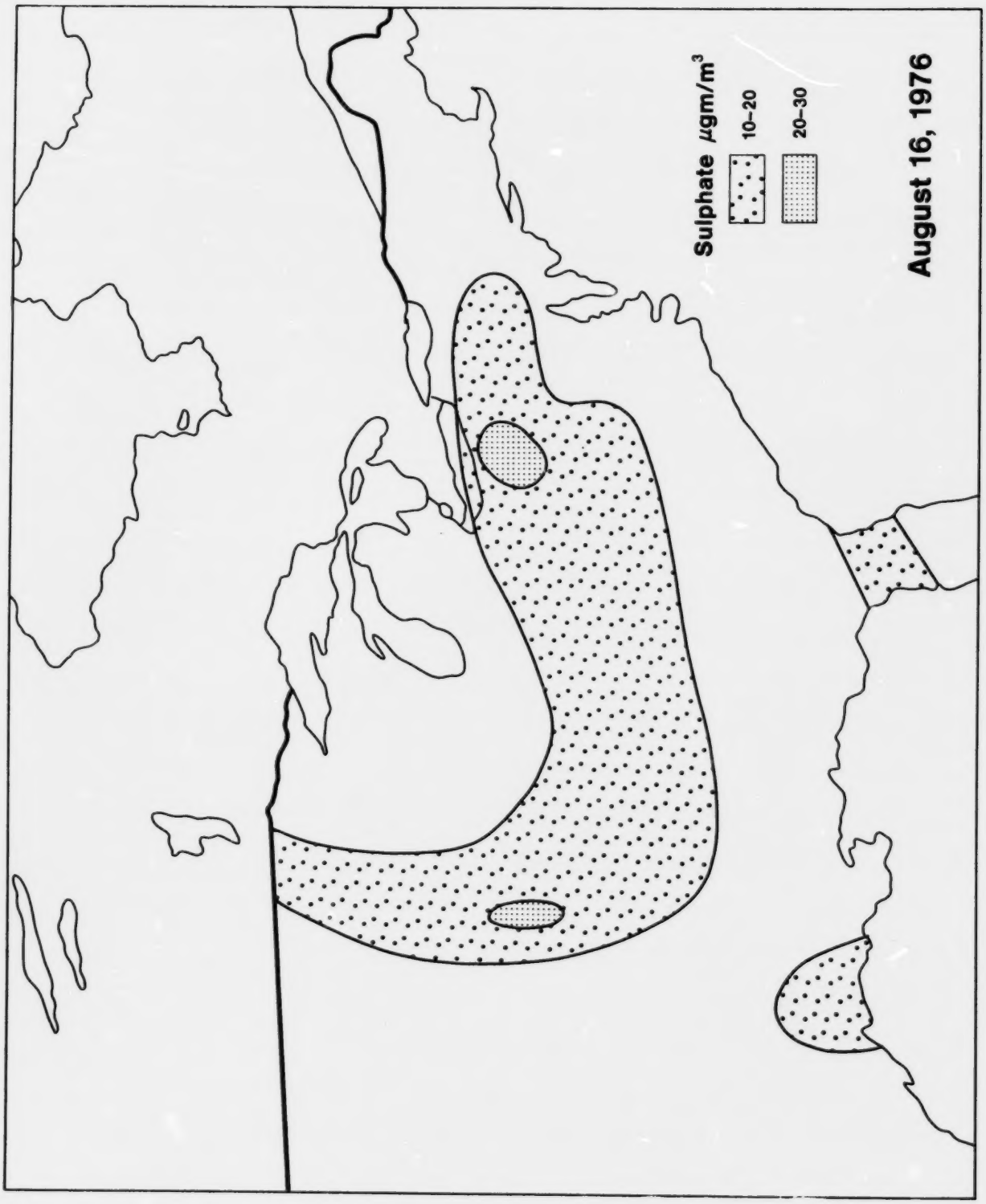

Figure 5.1 Day 1 of a typical episode demonstrating developement of high sulphate concentrations over Ontario.

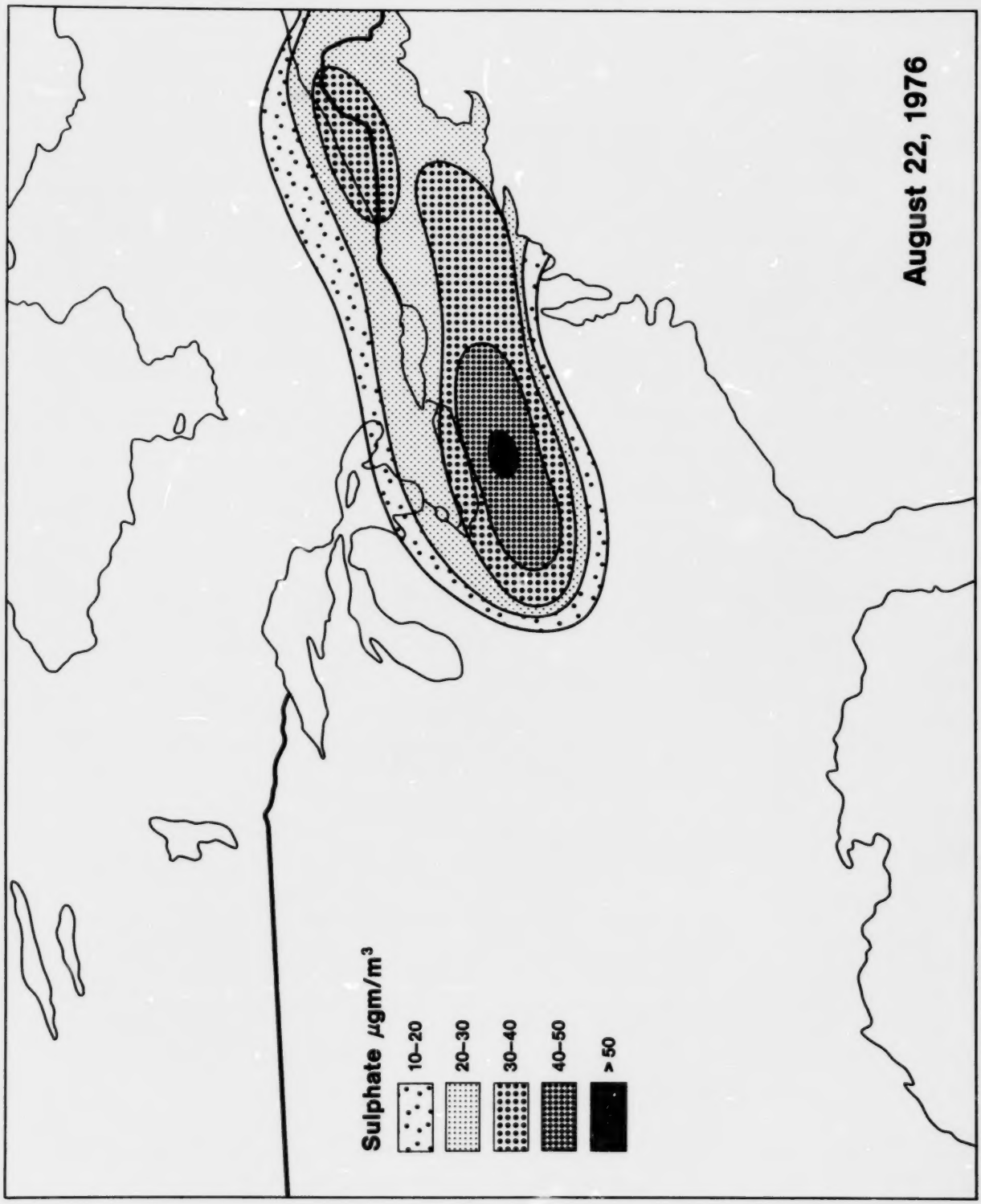

Figure 5.2 Day 7 of a typical episode demonstrating development of high sulphate concentrations over Ontario.

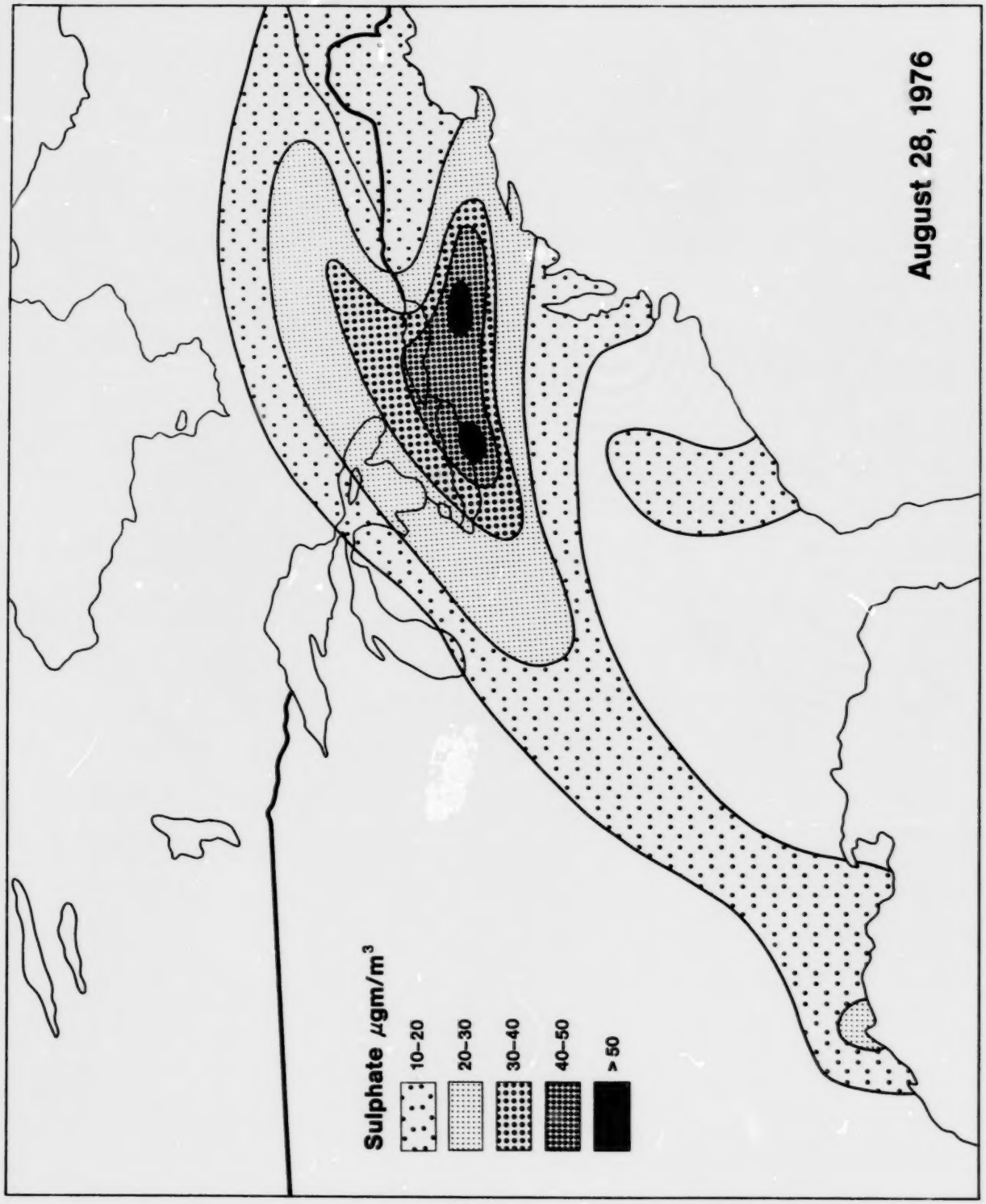

Figure 5.3 Day 13 of a typical episode demonstrating development of high sulphate concentrations over Ontario.

Therefore, the importation of U.S. pollution was directly responsible for unacceptable air quality in Ontario, and this U.S. pollution forced a temporary curtailment of Ontario industrial operations.

Studies of particulate nitrate[22,23] have shown that nitrate concentrations exhibit similar patterns to sulphate and ozone with high concentrations occurring during periods when air flows into Southern Ontario from the south. Detailed study of periods of widespread elevated nitrate concentrations (in excess of 10 $\mu g/m^3$) showed air originating south of the Great Lakes. Further analysis has shown that when an air mass moves over Southern Ontario after having passed over the States south of the Great Lakes, nitrate concentrations are nearly twice those measured when the air mass originates from the north.

5.4 Wet Acid Deposition and the Weather

5.4.1 Background

Pollutants can be removed from the air and deposited to the ground by precipitation (i.e. rain, fog, or snow). This is known as wet deposition. In the case of wet acid deposition, the substance of concern is hydrogen ion. The dissolved oxides of sulphur and nitrogen in precipitation give rise to its acidity.

As with dry deposition, recent studies[32,33] have advanced the state of knowledge regarding how precursor compounds are transformed, removed and deposited by precipitation. The relationships are complex, but a reasonable layman's summary can be presented as follows: (a) the primary pollutant emissions consist largely of SO_2 and/or NO_x; (b) deposition mechanisms may "bring down" part of the emissions locally if the meteorological conditions are appropriate, or the pollutants may be carried long distances; (c) chemical transformations may occur during transport via differing mechanisms, depending on whether the air is dry or moisture-laden; and (d) wet deposition occurs with precipitation at large distances from the sources.

5.4.2 Measuring Acidity in Precipitation

Measurements of the wet deposition of acidity are obtained by the chemical analysis of collected rain and snow samples. Scientists gauge the acid and base strength of a solution by a parameter called pH which is a logarithmic measure of the hydrogen ion concentration on a scale ranging from 1.0 to 14.0. On the pH scale, a chemically neutral solution has a value of 7.0 which is mid-way on the scale. The greater the acidity, the lower the pH value. A change of one pH unit downward defines a tenfold change in the hydrogen ion concentration, or a tenfold increase in acidity; a change of two is a hundredfold. If for example, a pH is 4.0 it is 10 times more acidic than a pH of 5.0; a pH of 3.0 is a hundredfold more acidic than a pH of 5.0.

There are several precipitation monitoring networks operating in North America. Figure 5.4 illustrates pH isopleths based on data from two of these networks for 1979.[34] The normal pH level of precipitation is 5.6; that is, slightly acidic. However, when the precipitation contains oxides of sulphur and nitrogen, its acidity increases. Figure 5.4 indicates that the acidity levels of precipitation are very severe in the Northeastern U.S. and Southeastern Canada, with the highest levels in the vicinity of the Lower Great Lakes where the pH is near 4.0. This acidity is thus about 40 times that of normal precipitation.

Precipitation at a pH level of less than 4.5 (about 10 times more acidic than normal) will cause damage to sensitive lakes, as discussed in Chapter 6. The data for 1979 shows an area of damaging acidic precipitation over most of Ontario, except the northwest portion, over southwestern Quebec, and over most of the northeastern United States. It is this area that we have shown to be subjected to the long range transport of pollutants from sources that are the subject of the Proceedings. Simulation modelling results, which follow in Chapter 7, will quantify the contribution of these sources.

5.4.3 Evidence of Contribution from Southerly and Northerly Sources

The most frequent type of storm system which gives rise to precipitation in the southern portion of Ontario first

passes over the areas of high emissions in the Great Lakes States.[35] These storms occur with a frequency of 15 to 25 times per annum. A typical example, is the track of a low pressure area originating in Eastern Texas, as shown in Figure 5.5. The low pressure system intensifies as it moves north-eastward towards the Great Lakes, bringing warm humid air northward from the Gulf of Mexico. This air passes across the industrialized Ohio River Valley, becoming laden with oxides of sulphur and nitrogen prior to entering Ontario and the Northeastern United States. A significant proportion of these pollutants is chemically transformed during travel to particulate sulphates and nitrates, which are eventually scavenged (i.e. removed) from the air by tiny water droplets. These, after growing in size, form acidic precipitation which can be deposited onto Eastern Canada or the Northeastern United States.

The significance of this situation has been well documented by an Ontario Ministry of the Environment study.[36] Weather maps were analyzed along with precipitation samples taken over a three year period in the Muskoka-Haliburton region, an environmentally sensitive area of South-Central Ontario. This region lies about 200 km North of Toronto and about 200 km Southeast of Sudbury, where Ontario's largest smelter sources of SO_2 are located. Back trajectory analyses[37] showed that 75% of the precipitation events at the site were associated with air masses arriving from the south and southwest octants. Furthermore, analysis of the precipitation samples showed that approximately 80 per cent of all acid

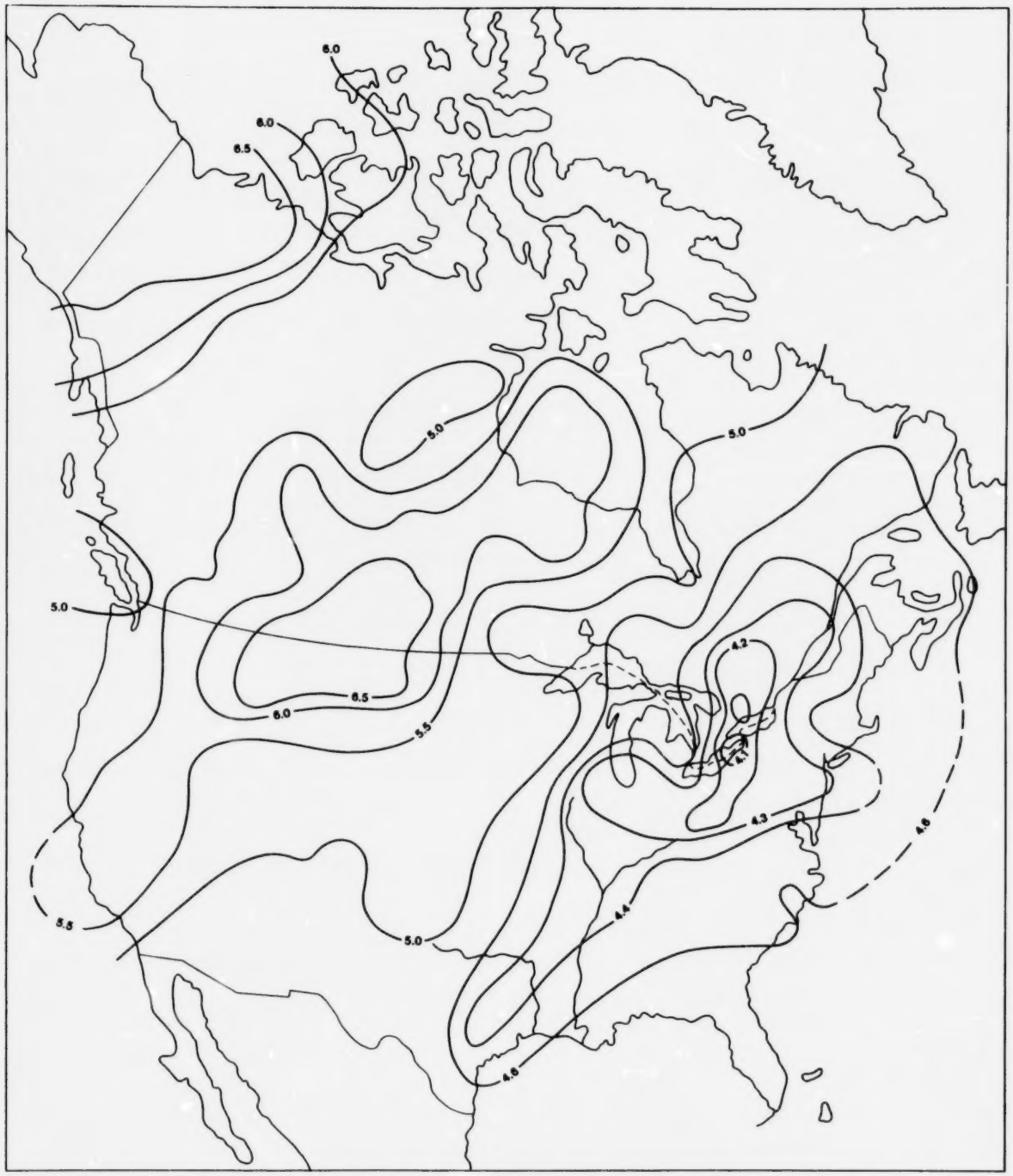

Figure 5.4 **NATIONAL ATMOSPHERIC DEPOSITION PROGRAM–NC141**

pH Annual Average–1979
Precipitation-weighted
NADP & CANSAP DATA
February, 1981

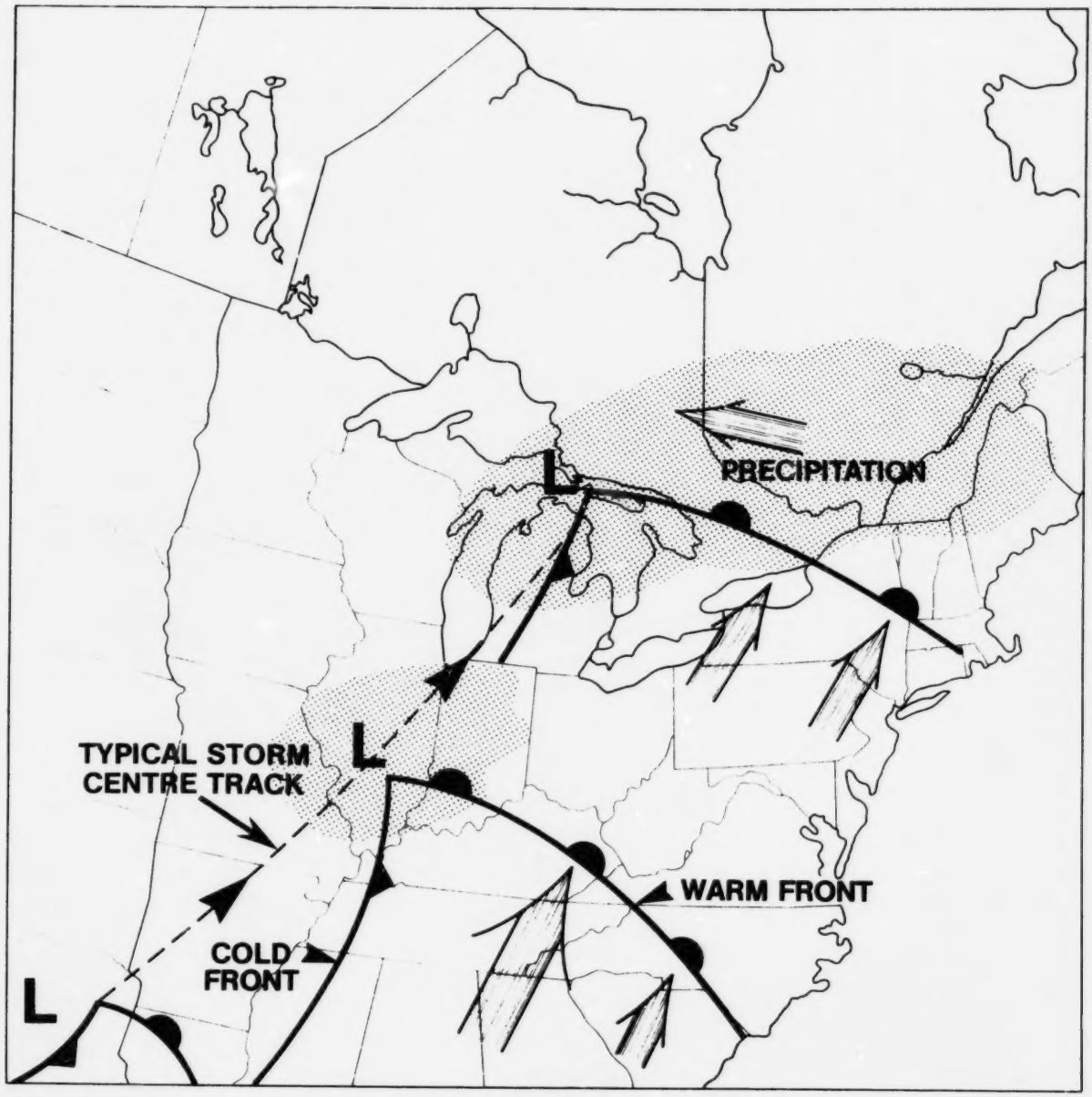

Figure 5.5 Typical storm track across Central United States and into Ontario.

which was wet-deposited came with air masses from the south and southwest. While Canadian sources to the south also contribute to this percentage, the relative magnitude of these sources is very small compared to the size of the U.S. emissions south of Muskoka-Haliburton. Thus, it is reasonable to assign most of the 80 per cent figure to U.S. sources. Other studies[20,38] have also shown that the high acidity in precipitation over Ontario occurred in conjunction with air masses that originated in the United States.

A second study done by the Ontario Ministry of the Environment reinforces the above conclusion.[39] A series of wet deposition measurements (i.e. precipitation event samples) were taken in the Sudbury area, and careful records were kept of the weather conditions and the direction taken by the smelter plumes. While interesting results were obtained concerning the amount of wet deposition due to the local smelter plumes, the study also demonstrated that the pH of precipitation associated with northerly winds was on average 4.6, while the pH value of precipitation associated with southerly winds was 4.2. Therefore, the acidity of precipitation related to southerly air masses was more than twice as great as that of precipitation from the north.

5.5 Summary

This chapter has presented evidence from a variety of fields which clearly and convincingly documents the fact that the states containing the power plants in these reports

are causing a significant amount of the acid deposition occurring in Ontario. Chapter 7 will quantify the part of this deposition due to the 20 power plants under consideration, and Chapter 6 will discuss the effects this deposition is causing, but it should be clear from this chapter that:

- weather systems can frequently move air masses over long distances;

- emissions of SO_2 and NO_x from U.S. sources are mixed into these air masses and react as the air masses are transported to form acidic compounds;

- these air masses can then either dry-deposit or wet-deposit acidic material onto Ontario's sensitive areas with a significant frequency;

- experimental measurements of wet deposition, and meteorological analysis coupled with air quality measurements, verify that the U.S. has a significant impact on the deposition in Ontario.

These points all reinforce the necessity of the E.P.A. Administrator to work closely and conscientiously with other jurisdictions sharing the northeastern continental airshed in order to judge before the fact whether or not SIP relaxations will adversely affect the environment anywhere in that airshed.

REFERENCES - CHAPTER 5

1. Acid deposition is the technical term used to describe the removal of material out of the atmosphere onto the earth's surface. The word "acid" means that the materials being deposited onto lakes, rivers, forests, crops or soils of the planet contain hydrogen ion as a constituent of the material--for example, the material H_2SO_4 (sulphuric acid) contains hydrogen ion (H^+) and sulphate ion (SO_4). In technical terms, deposition can occur two ways: via "wet" or "dry" mechanisms. In the "wet deposition" mode, the acid-bearing material comes down as part of rain, fog or snow. "Dry deposition" occurs when gaseous or particulate (i.e. dust or aerosol) matter impacts on the earth's surface out of the atmosphere.

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14. Canada/U.S. Work Group 3A: Strategies Development and Implementation Interim Report, February 1981.

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6.

EFFECTS OF ACID DEPOSITION ON ONTARIO'S AQUATIC SYSTEMS

Sensitive aquatic systems which receive acid, both directly and indirectly from precipitation, can suffer chemical and biological damages. This chapter discusses the nature and magnitude of these effects in Ontario as evidenced through research on the province's aquatic ecosystems.

6.1 General Nature of the Lake and River Acidification Process

Acids falling on the earth's surface may be neutralized by chemical reaction with basic materials in the soil and water. Soils with large amounts of basic material, such as limestone, can neutralize the acids for indefinite periods of time with only minor changes in the chemical composition of the runoff. If, however, the soils have little capacity to neutralize the acid, for example, Precambrian rock, the acid loading can exceed the neutralizing capacity and runoff water will be acidic with consequential biological damage in streams and lakes.

The alkalinity of lake and river water is a chemical measure of its capacity to neutralize acid. The greater the alkalinity, the higher the pH value will be

and the greater the capacity to neutralize acid. The alkalinity is often referred to as the buffering capacity of the water. Lakes in areas of limestone soils have high alkalinities and pH values generally above 7.0. By contrast, unpolluted lakes located in hard rock geological conditions, such as the Precambrian rock area of Ontario, have low alkalinities and pH values generally in the range of 6.0 to 7.0. While these lakes are on the acidic side of pH 7.0, they still have healthy aquatic life and vigorous fish populations.

Lakes with low alkalinity are regarded as sensitive to the effects of acid rain since they have a low capacity to maintain (or buffer) the pH at acceptable values when excessive acid is added from the atmosphere.

When excessive acid loadings from the atmosphere are applied to sensitive areas, the pH of the runoff may be reduced to values well below 6.0 for a few weeks time during spring snow melt or for a few hours or days during heavy summer and autumn rains. In addition to these short term effects, the soil alkalinity or buffering capacity can be slowly used up by the acid and therefore, the pH of the streams and lakes is reduced throughout the year. Lakes which suffer short term pH depression or have their summer pH values slightly reduced are called "acid stressed" lakes.

Over time, the acid loading can virtually exhaust the neutralizing (or buffering) capacity of the soils in sensitive areas and the runoff can become nearly as acidic as the rainfall itself. When the pH of streams and lakes falls to values of about 4.5 or less, fish populations will be essentially absent and the waterbody is called "acidified".

Therefore, the ultimate result of deposition of acids in sensitive areas is acidification of the surface water with virtually complete destruction of aquatic life except for some attached algae and mosses growing on the lake bottom. These effects have been well established for lakes and rivers in Scandinavia affected by acid deposition.[2]

6.2 Research Approach to Aquatic Effects

Under the current patterns of acidic precipitation, virtually all of the lakes located in Precambrian rock in Ontario are being subjected to acid loadings above "background" levels. Precipitation with pH near 5.6, the value expected for equilibrium with atmospheric carbon dioxide, contains about 2.5 μeq/l of acid (hydrogen ion). The observed concentrations in bulk deposition

are about 11 μeq/l at Kenora* (4 times the "background" level[23] and up to 70-90 μeq/l in the important recreational areas of Muskoka-Haliburton** (28-36 times the "background" level[21]). For several years, environmental studies have been undertaken in these areas designed to determine the resulting water quality and biological responses in the lakes and streams. Data presented in this section are derived from these studies.

The lakes, rivers and watersheds themselves are the ultimate "collectors" of atmospheric pollution deposited by wet and dry mechanisms. One research approach has been to consider lakes and watersheds as giant collectors, which has led to establishing "calibrated watersheds", which are combinations of watersheds, streams and lakes under intensive measurement. The calibrated watersheds are the prime source of information on acid rain effects.

Hydrologic weirs (Figure 6.1) are set up on the streams entering and leaving a particular study lake. The flows of water and dissolved substances are accurately measured entering and leaving the lake and these are

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*Located in Northwest Ontario, Northeast of the Ontario-Minnesota Border. Area Code 2 Map 2.1.

**Located in South-Central Ontario. Area Code 1 Map 2.1.

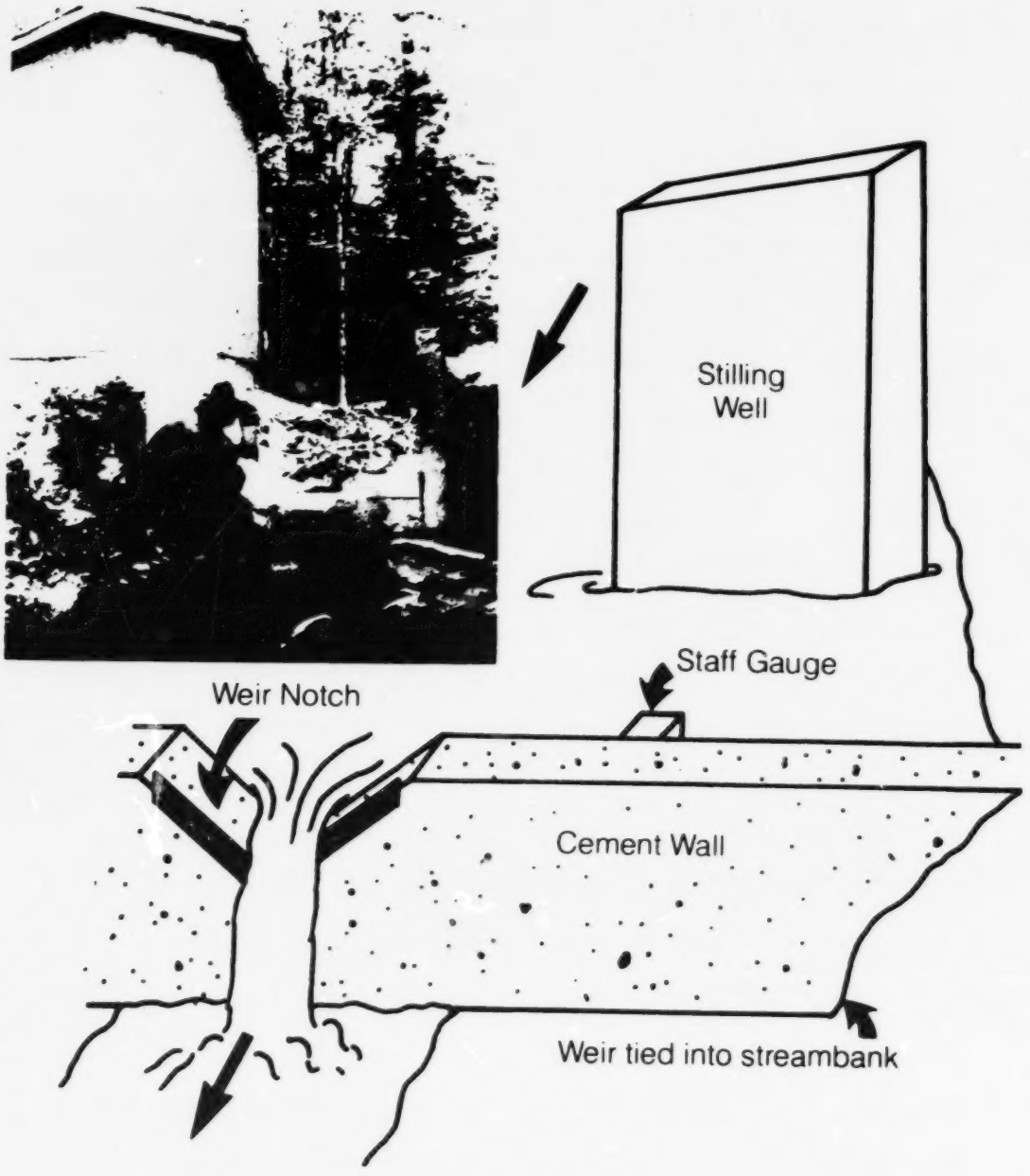


Figure 6.1 Actual and schematic examples of a weir designed to accurately record the flow of water in streams. Water samples are frequently collected for chemical analysis and concentrations and total amounts of chemical constituents passing through the weir are calculated.

combined with the best possible measures of atmospheric inputs and of water loss by evaporation to calculate "substance budgets".

The difference between the inputs measured by the budgets and the inputs measured from wet deposition can give estimates of dry deposition.

The calibrated watersheds are subjected to detailed biological sampling and thus, serve to quantify the chemical and biological effects of pollutant deposition. Relationships established by detailed studies can be extrapolated to large numbers of lakes for which less total data are available.

Calibrated watersheds have been established at many locations such as Kenora, Sault Ste. Marie and Dorset in Ontario, Laurentide Park in Quebec, Kejimkujik Park in Nova Scotia, Hubbard Brook in New Hampshire, and Sagamore Lake in New York. For each study site, a data base of atmospheric loadings and resulting aquatic and terrestrial effects is being compiled. Conclusions regarding effects are drawn from comparisons between areas and from long term observations in each area. Extensive results for Ontario are available from the Kenora and Dorset study locations.

6.3 Observed Effects of Acid Rain in Ontario

6.3.1 Water Quality

Some lakes near Sudbury, Ontario, where nickel and copper smelters have discharged large amounts of sulphur dioxide since the early 1900's, have been acidified by atmospheric deposition of acids[4,10]. The problem was regarded as "local" and was addressed by reducing emissions and by commissioning the world's highest smoke stack in 1972 to utilize the dilution capacity of the atmosphere for the largest single sources in the area. Ground level sulphur dioxide concentrations due to the local sources had caused discomfort to people and damage to vegetation and both problems have essentially been eliminated by the control programs.

The Sudbury situation is famous because of its size, particularly the INCO Ltd. smelter, but it is far from unique. During the 1970's hundreds of other plants and industries were built in the United States and Canada which utilized high stacks to disperse wastes. Emission reductions were seldom applied; the atmosphere was expected to solve the "problem".

The overall result is that today in North America there are hundreds of atmospheric sources of sulphur and nitrogen oxides from the burning of fossil fuels and non-ferrous smelting operations, all depending on atmospheric dilution to resolve part of the waste problem.

In recent years it had become well understood that the acid rain problem in Ontario was not confined to the Sudbury area and that the Sudbury sources were only a small part of the total emissions to the atmosphere leading to the acid deposition in Ontario.

In most parts of the Precambrian Shield, the acids (hydrogen ions) from atmospheric deposition are neutralized during most of the year. Retention (neutralization) of hydrogen ion has been measured at 88% and 98% on an annual basis at Kenora and Dorset respectively.[22,23]

However, many detrimental water quality effects are being observed. The hydrogen ions stored in the snow runoff in the spring thaw and most of the total annual acid input occurs during the spring melt. The large volume of water, coupled with less chance for interaction with the soil, which may be frozen, results in shock loadings of acid to streams and to the surface waters of lakes.

Jeffries[17] compared pH values of a series of small streams and lake outflows at Dorset before and during spring runoff. (See Table 6.1). At the very minimum, the surface waters of the entire lakes were acidified during this period of time. The lowest pH values, 4.8 - 5.0, observed in lake outflows, are within a range capable of causing damage to aquatic life, particularly to fish. As much as 76.6% of the measured yearly acid discharge from the watersheds ran off in April. Figure 6.2 shows a typical hydrograph for one of these streams, emphasizing the high spring water flow, high acid discharge, and low pH values. Scheider[22] further demonstrated that the pH of streams was depressed for periods of a few hours during times of heavy runoff during the summer months (Figure 6.3).

TABLE 6.1

pH OF STREAMS IN MUSKOKA-HALIBURTON, ONTARIO, CANADA:
STREAM pH IS GIVEN PRIOR TO SPRING RUNOFF (MID-MARCH 1978)
AND AT MAXIMUM RUNOFF (MID-APRIL 1978)

Annual Average Alkalinity data from Scheider (Pers. Comm)

Waterhsed	Annual Average Alkalinity µeq/l	Stream Number	pH	
			Mid-March	Mid-April
Harp Lake	96	3	6.1	5.1
		3A	6.0	5.6
		5	5.9	4.8
		6	6.2	5.3
		6A	5.4	5.0
		Outflow	6.3	5.0
Dickie Lake	55	5	4.6	4.3
		6	4.6	4.4
		11	4.9	4.1
		Outflow	5.6	4.9
Chub Lake	61	1	5.8	5.1
		2	5.2	4.7
		Outflow	5.5	4.8
Red Chalk Lake	92	1	6.1	5.6
		2	4.5	4.3
		3	6.0	5.5
		4	6.2	5.5
		Outflow	6.1	5.9

Partial Table From: Jeffries et al., 1979

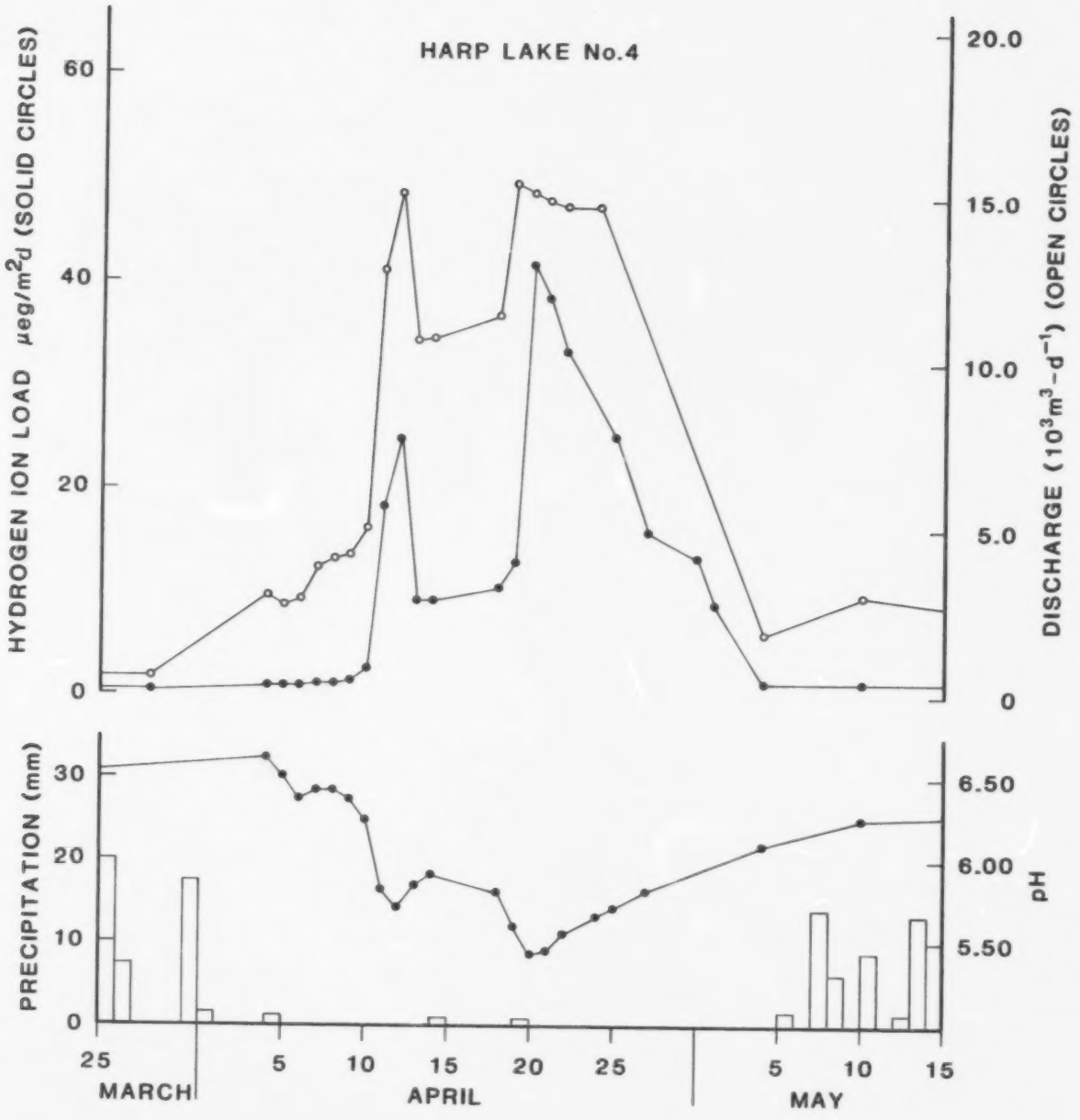


Figure 6.2 "Spring pH Depression" of a Stream
Graph illustrating "spring pH depression" in one of the six inflowing streams to Harp Lake, a study lake in Muskoka. As the spring runoff increases the amount of water, the acidic melted snow causes the stream pH to drop, producing severe chemical "shock" effects on aquatic life.

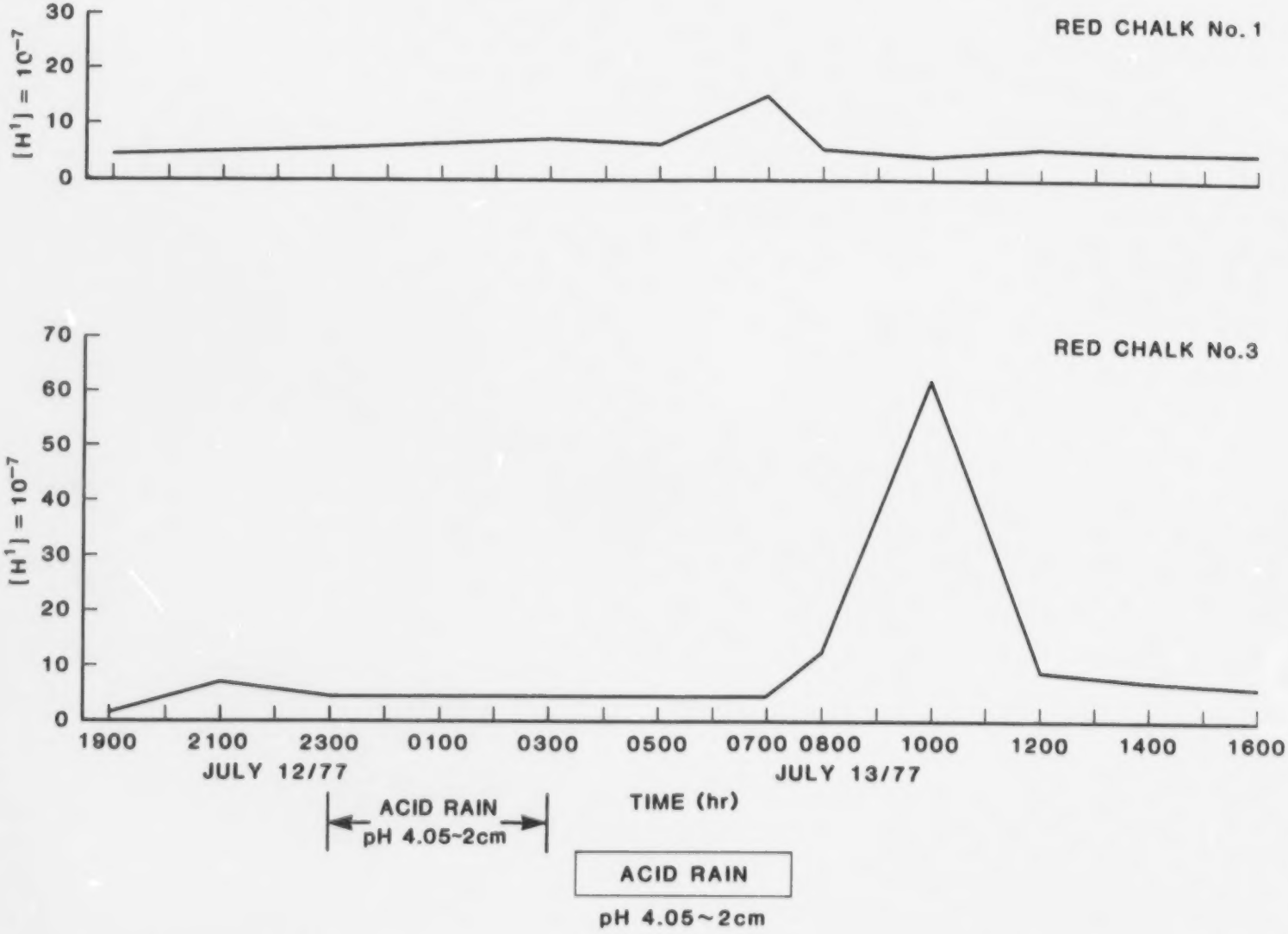


Figure 6.3 Hydrogen ion content of streams draining Red Chalk Lake watersheds No. 3 and No. 1 (Dorset, Ontario) showing effects of a 2cm rainfall (pH 4.06) between 11:00p.m. July 12 , 1977 and 3:00a.m. July 13, 1977 (Scheider et al., 1978).

Heavy autumn rains also cause depressed pH in runoff for a few days at a time. In one particular year of study, Jeffries[17] observed as much as 25.8% of the total annual hydrogen ion runoff from small watersheds in October.

There are about 35 streams under study in the Dorset calibrated watersheds and some have results for a period of five years. The results for the Harp and Red Chalk Lake watersheds presented here are typical of the full set of observations and it can be concluded that atmospheric acid loadings are causing periodic water quality changes. The study lakes all have low alkalinities but are representative of thousands of lakes in the Precambrian area.

The summer alkalinity value of Clear Lake in McLintock Township at Dorset, was 33 μeq/l in 1967 and only 14 μeq/l in 1977 indicating a net loss of buffering capacity,[12] in other words, the lake is acid-stressed. This lake is only unique in that accurate historical data were available. There is no reason to doubt that many other sensitive Ontario Lakes have already shared the same fate and that many thousands more will follow in due course if no abatement action is taken.

Table 6.2 indicates the distribution of alkalinity values for various areas of the Precambrian Shield.

The number of lakes sampled in each area to date, (Table 6.2), is small in comparison to the total lakes in these areas, but based on this data it is becoming clear that a very high percentage of the lakes in the entire Precambrian Shield fall in the extremely or moderately sensitive categories.

The lakes in the extreme sensitivity category are currently acid stressed (suffer pH depression in the spring runoff) and are likely to be acidified by long range transport if current acid loadings continue. Loss of buffering capacity is cumulative, its rate and timing dependent on the rate of deposition. Once lost, there is nothing to prevent the lake from quickly acidifying. This supposition is supported by the long term observations of lake acidification in Scandinavia[7] and the Adirondacks.[20]

6.3.2 Ground Water

Hultberg[16] has identified a number of shallow wells in Sweden which have become acidic as a result of acidic precipitation infiltrating soils with very low neutralizing capacity. The acid water has caused serious corrosion of plumbing and in some cases entire systems of copper pipes have had to be replaced after 10 to 15 years of use. The acidic wells are characterized by rock outcrops allowing surface runoff to move to sandy subsoil with minimal contact with surface soils. There is little opportunity for the neutralizing capacity of the surface soils to be utilized in neutralizing the runoff.

TABLE 6.2 SUMMARY OF THE PERCENTAGE OF LAKES IN EACH ALKALINITY CLASS BY COUNTY OR DISTRICT

County or District	Percentage of Total No. of Lakes in each Alkalinity Class					
	Acidified (≤ 0 µeq/l)	Extreme Sensitivity (>0 to 39.9 µeq/l)	Moderate Sensitivity (40 to 199 µeq/l)	Low Sensitivity (200 to 499 µeq/l)	Not Sensitive (≥ 500 µeq/l)	Total No. of Lakes Surveyed In County/ District
Algoma District	5	11	30	28	26	163
Bruce Co.					100	7
Cochrane Dist.		7		11	82	27
Durham Co.					100	1
Frontenac Co.				6	94	64
Grey Co.					100	3
Haliburton Co.		24	39	22	15	112
Hastings Co.			21	11	68	63
Huron Co.					100	1
Kenora Dist.			14	25	61	88
Lanark Co.					100	15
Leeds Co.					100	24
Lennox &			36	12	52	25
& Addington Co.						
Manitoulin Dist.	52	29	3	3	13	31
Middlesex Co.					100	1
Muskoka Dist.	1	30	61	2	6	115

. . .continued/

TABLE 6.2 SUMMARY OF THE PERCENTAGE OF LAKES IN EACH ALKALINITY CLASS BY COUNTY OR DISTRICT

County or District	Percentage of Total No. of Lakes in each Alkalinity Class					
	Acidified (≤ 0 µeq/l)	Extreme Sensitivity (>0 to 39.9 µeq/l)	Moderate Sensitivity (40 to 199 µeq/l)	Low Sensitivity (200 to 499 µeq/l)	Not Sensitive (≥ 500 µeq/l)	Total No. of Lakes Surveyed In County/ District
Nipissing Dist.		9	75	13	3	75
Northumber-land Co.					100	1
Ontario Co.					100	5
Parry Sound Dist.	5	20	64	10	1	107
Peel Co.					100	1
Peterborough Co.		4	16	6	74	49
Prince Edward Co.					100	3
Rainy River Dist.		3	64	19	14	99
Renfrew Co.			8	32	60	50
Simcoe Co.					100	7
Stormont Co.					100	1
Sudbury Dist.	24	29	23	12	12	210
Thunder Bay Dist.	1	2	25	27	45	136
Timiskaming Dist.	13		7	27	53	30
Victoria Co.					100	11
York Co.					100	2
						1,527

Many wells in the Precambrian area of North America servicing seasonal cottages and permanent homes are located in similar geological conditions so the potential for acidification of ground water exists. The first field surveys were carried out in 1980 in the Muskoka-Haliburton area of Ontario. A total of 85 ground water samples were analyzed for pH. Sampling was done in July along a line between McTier and Bancroft, and in October along a line between Parry Sound and Barry's Bay. Ground water was sampled from shallow springs and at various depths in wells obtaining water from both bedrock and overburden formations.

The sampling results indicated the acid shock effects of the spring snow melt on ground water sources. Eleven of the 85 samples had pH values less than 6.0, with the lowest value being 5.2. Subsequent sampling (summer, fall) of five of the low pH values resulted in only one sample still having a pH of less than 6.0.

6.3.3 Fisheries Damage

Fish population damage is a major concern as it represents loss to the sport fishing industry and serious disruption of the biological food chain since so many birds and mammals depend on fish for food. Complete loss of fish tends to be regarded as the definition of a "dead" lake.

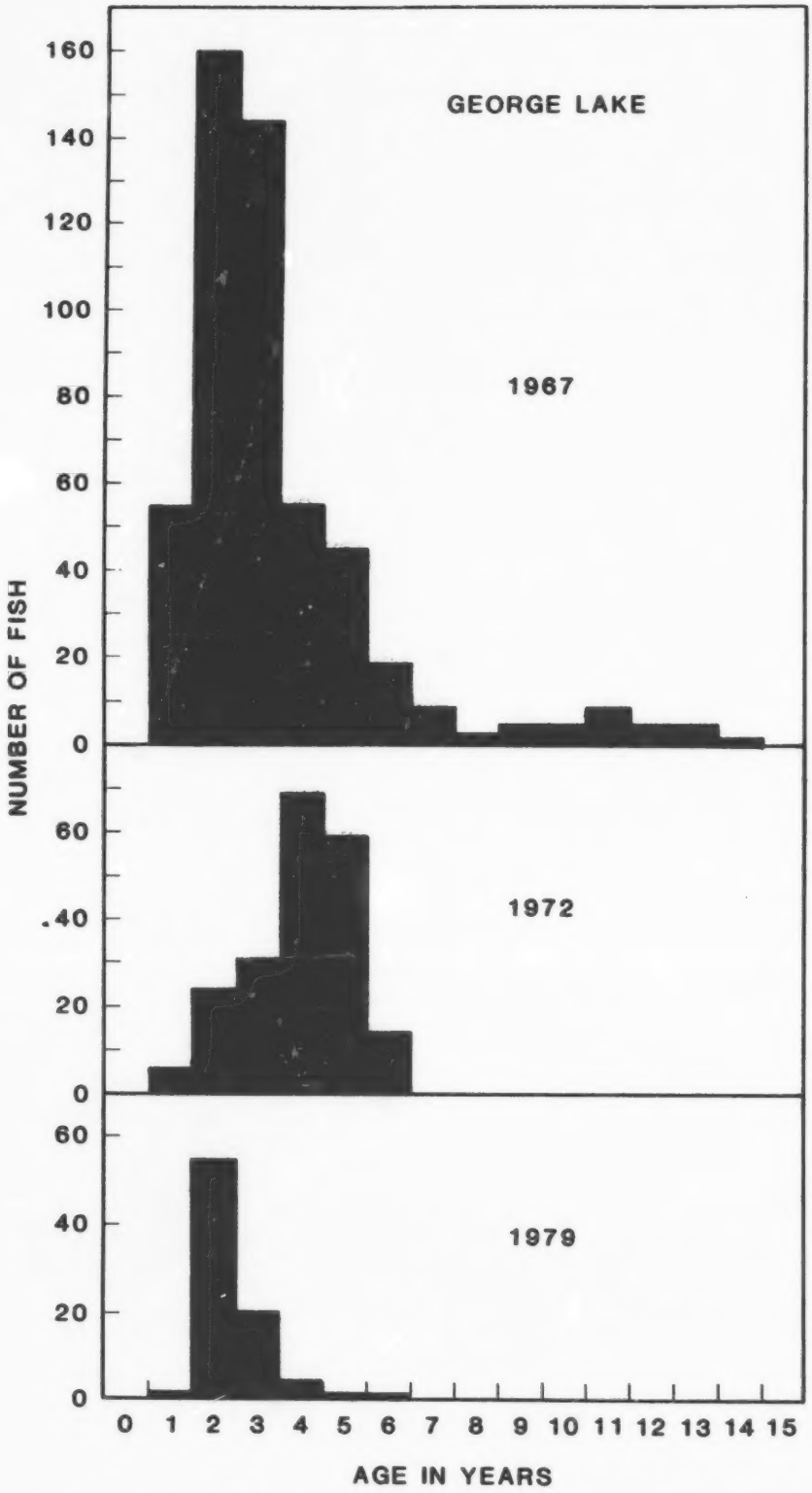


Figure 6.4 Changes in the age composition of the White Sucker in George Lake, Ontario. See text for references.

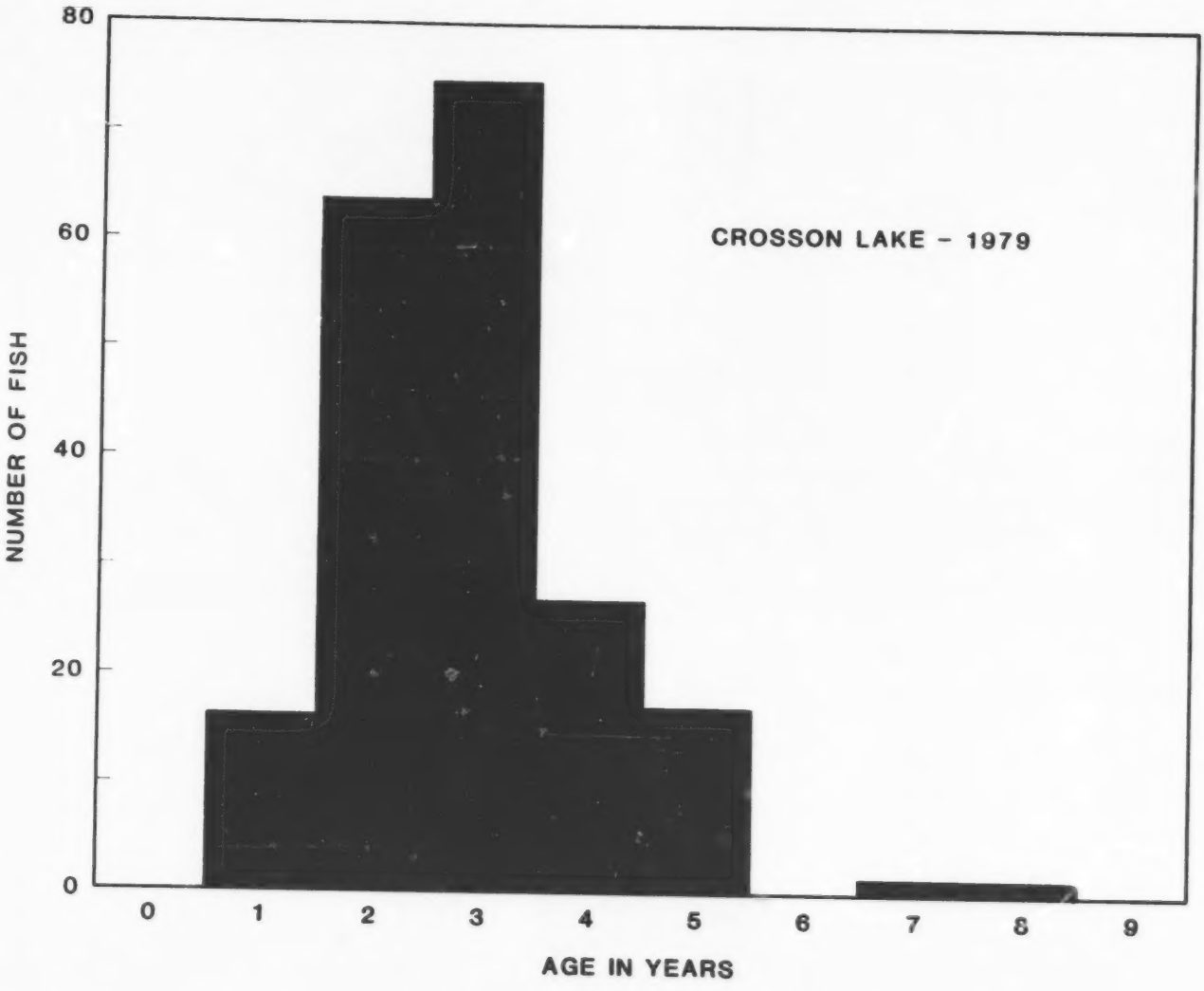


Figure 6.5 Age composition of the White Sucker in Crosson Lake.

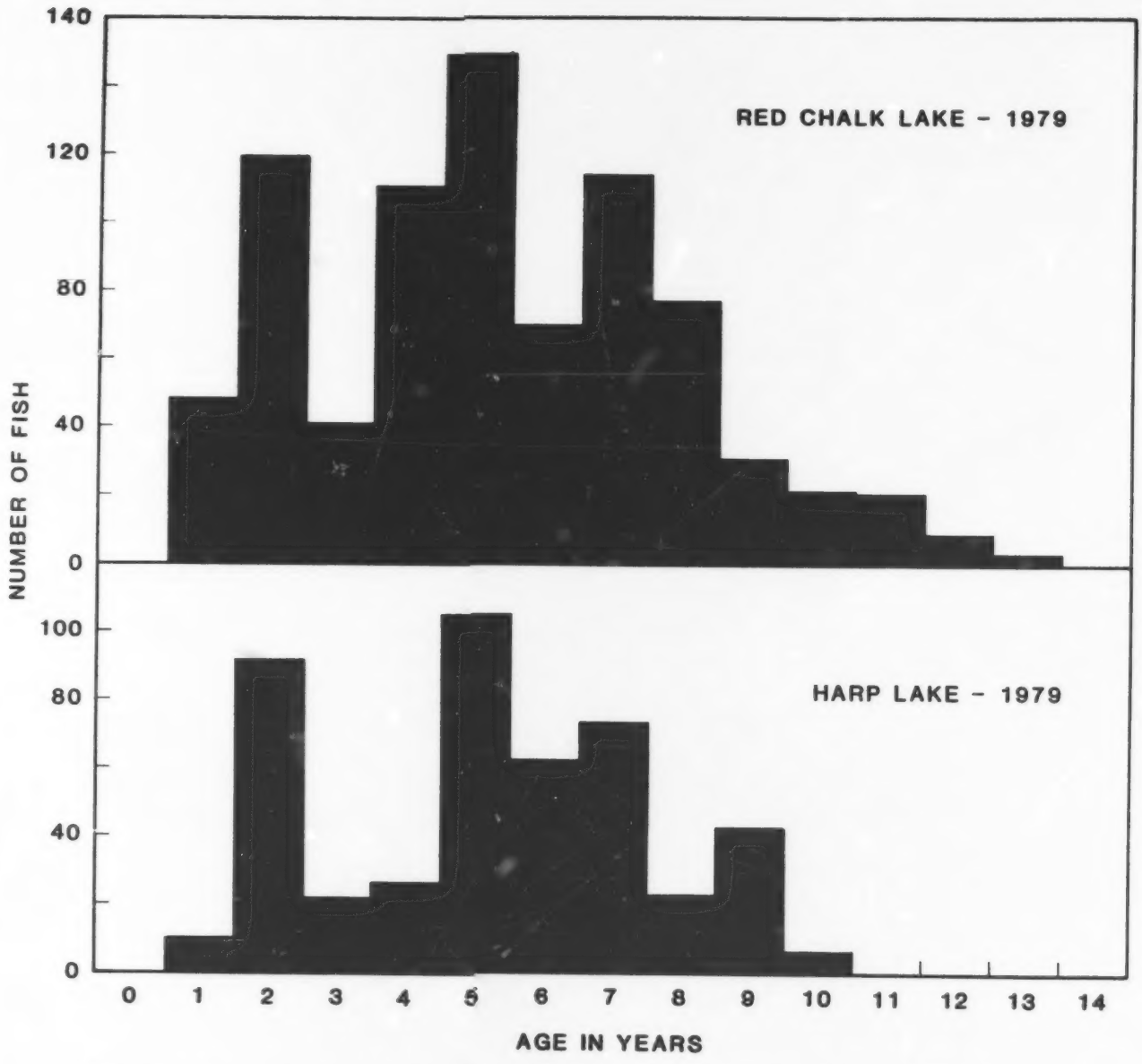


Figure 6.6 Age composition of White Sucker for Harp and Red Chalk Lake, 1979.

When the buffering capacity of a lake has been reduced and the summer pH drops below about 5.5 the fish population declines rapidly. Virtually no fish survive for long at pH below 4.5[3].

A small number of lakes at Dorset have been subjected to intensive fish population measurements and several observations are relevant.

Four study lakes (calibrated watersheds) have average pH values of 5.7 (Plastic), 6.0 (Crosson), 6.6 (Red Chalk) and 6.6 (Harp). Corresponding alkalinities are 6, 61, 92 and 96 μeq/l respectively.

Plastic Lake has experienced fish kills during snow melt when the pH has been as low as 4.7 (Harvey, pers. comm.).

Figure 6.4 shows the age distribution of white suckers in George Lake near Sudbury during a 13 year period while the lake was becoming acidic.[2,5,14] There is a distinct shift toward a younger average age and this is believed to be a characteristic response to lake acidification. Figures 6.5 and 6.6 show the age distributon of white suckers in Crosson and Red Chalk Lakes in 1979. The shift toward a younger average age in Crosson Lake suggests damage by acidification - in this case the spring pH depression being the main manifestation of the phenomenon.

White suckers are an important "test species" since they are not subject to fishing pressure and therefore, any changes in population are due to environmental effects. Figure 6.7 shows the age composition for white suckers in Chub Lake with the year 4 age class missing. This is also a characteristic of lakes subject to acidification damage. (Harvey, pers. comm).

These observations provide strong evidence that the fisheries are beginning to suffer under the present acid loading conditions. It is reasonable to assume that similar changes are taking place in the many thousands of lakes with similar alkalinities which are likely experiencing similar water quality effects.

6.3.4 Mercury in Fish

Since elemental, metallic mercury can exist in the gas phase at ordinary air temperatures it has become ubiquitous in the environment. Large quantities of mercury pass between the earth and the atmosphere by natural cycling processes which have been going on for millions of years. Therefore, the mere presence of mercury in any compartment of the environment does not necessarily imply any human influence.

Man's propensity to utilize the atmosphere for the disposal of wastes influences the natural mercury cycle

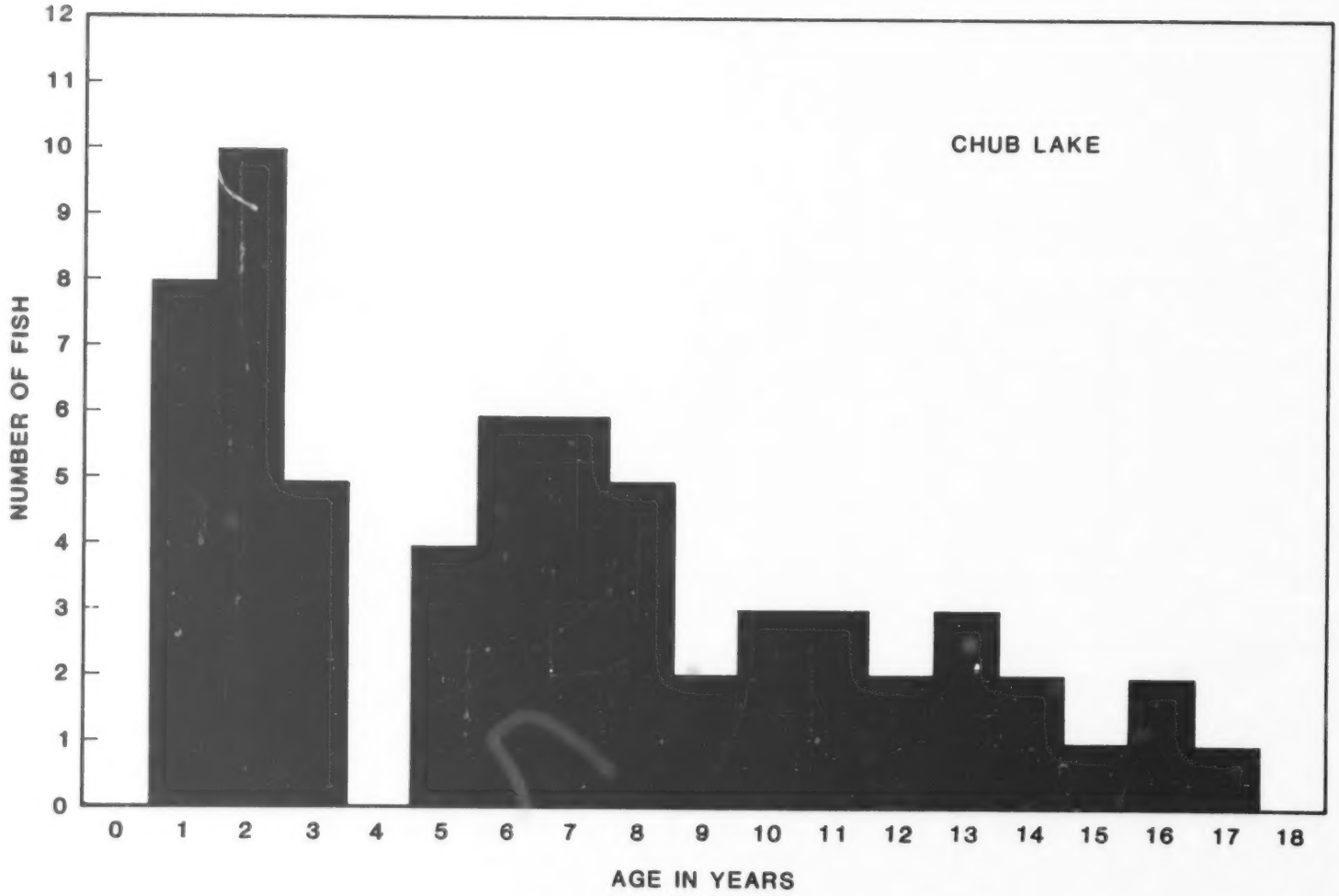


Figure 6.7 Age composition of White Sucker for Chub Lake 1979.

in two ways. Firstly, man's activities directly increase the total amount of mercury entering the atmosphere. Secondly, the amount of mercury in fish and other aquatic organisms is increased due to the acidification of surface waters by acid deposition.

Regarding the first influence, it has been estimated that on a global scale human activities have increased the mercury emissions to the atmosphere by 27%[18], but it is not known how this increase influences the global mercury cycle. Within eastern North America, however, the situation is quite different. Man-made mercury discharges to the atmosphere from the U.S. states bordering on the Great Lakes are 170% of the natural atmospheric loading.[18] States farther south which may still influence the Precambrian area by long range transport have similar man-made atmospheric discharges.

Coal contains on average about 60 ng/g of mercury[11] and up to 97% may be emitted from stacks upon combustion.[6] The mean residence time in the atmosphere has been estimated to be 11 days.[18] Therefore, there is plenty of time for long range transport prior to deposition. These points are of particular concern regarding any policy to increase the use of coal as an energy source.

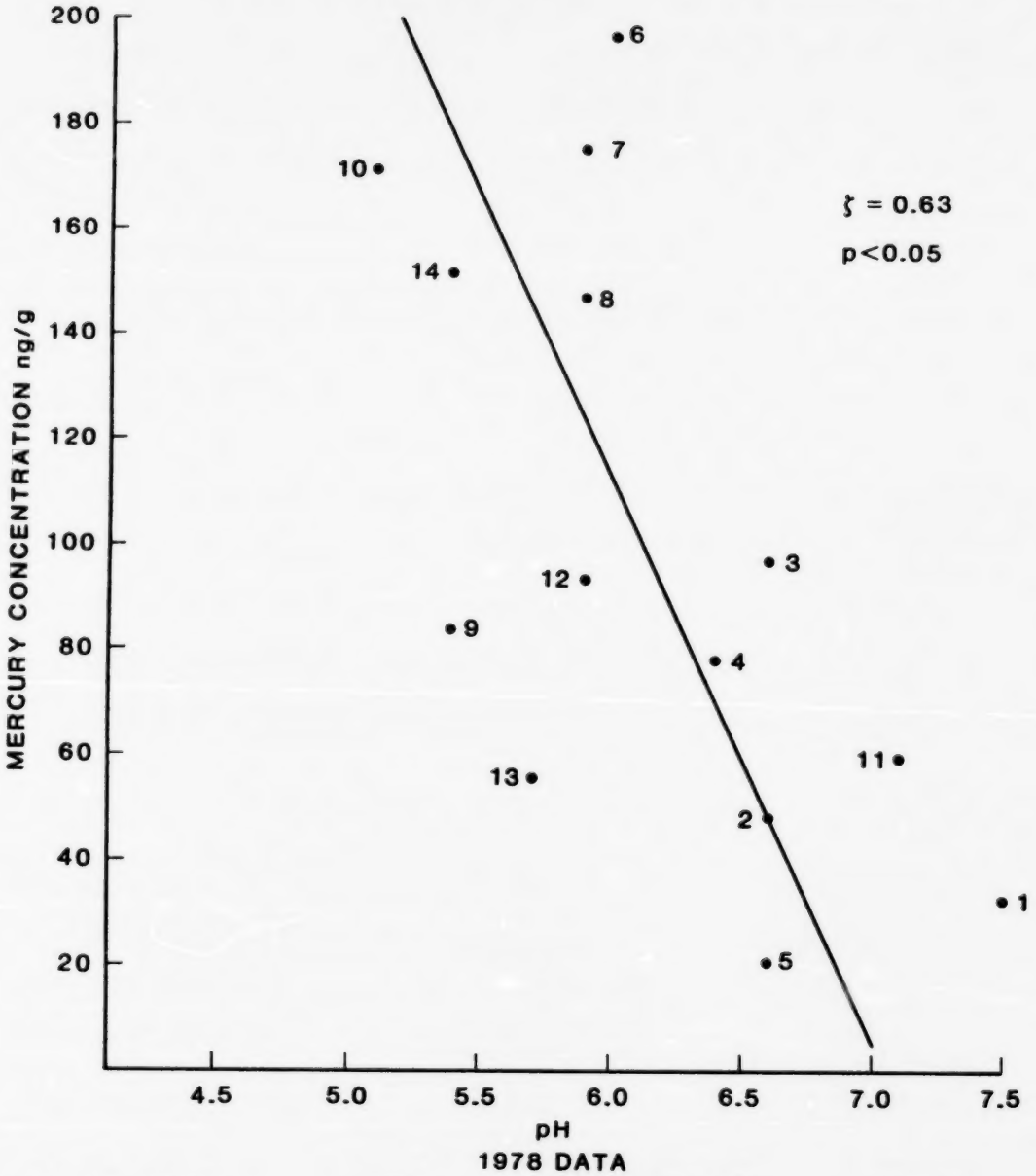
If all other factors were equal, one could expect such large increases in atmospheric emissions to increase

the deposition rate and hence, the concentrations of mercury in living organisms. However, while logical, increased deposition has not yet been fully substantiated as atmospheric studies on mercury have only been carried out in a preliminary way to date.

Regarding the second factor influencing the natural mercury cycle, that is, acidification of surface waters, it has already been demonstrated as cause for concern. Acidification of lakes takes place over a time period measured in years or even decades. During this time there will still be fish in the water although the average pH of the water will be slowly declining. It has been shown that the lower pH conditions tend to cause increases in the mercury concentrations in fish.[14,8,1]

One possible explanation of this is as follows: methyl mercury is generally in the dimethyl form which is a gas at room temperature with low solubility in water. It can move through the environment without much effect on biological systems. Under acidic conditions, the dimethyl mercury loses one methyl group and becomes ionic monomethyl mercury which is much more soluble in water and apparently more readily taken up by fish and other aquatic life. The methyl mercury form is extremely toxic to most life forms.

The result is, that over a long period of time, lakes and rivers subjected to acid stress will still have



LAKE #, NAME	TWP.	LAKE #, NAME	TWP.
1 DUCK LAKE	MINDEN	8 DICKIE LAKE	McLEAN
2 LITTLE CLEAR LAKE	SINCLAIR	9 LEONARD LAKE	MONCK
3 HARP LAKE	SINCLAIR	10 HENEY LAKE	McLEAN
4 BIGWIND LAKE	OAKLEY	11 CRANBERRY LAKE	GUILFORD
5 NELSON LAKE	BOWELL	12 HEALEY LAKE	McCAULEY
6 CHUB LAKE	RIDOUT	13 CLEAR LAKE	STANHOPE
7 CROSSON LAKE	OAKLEY	14 FAWN LAKE	McCAULEY

Figure 6.8 Mercury concentrations in yearling yellow perch and epilimnetic pH relationships (Suns et al., 1980).

some fish but the mercury concentrations in those fish will increase. Birds and animals which eat fish as a major part of their diet will ingest quantities of mercury which may well threaten their health and survival.

The fisheries within Ontario are the basic resource for a sport fishing industry valued at hundreds of millions of dollars per year. While in the long-term, acidification of lakes poses a threat to the industry, in the short-term, mercury in fish could lead to further restriction on human consumption of the fish with consequential economic loss to the industry.

Suns[24] has been sampling young-of-the-year and yearling fish for contaminant studies. This approach reduces some of the variables since the fish are uniform with respect to age and diet. The data, Figure 6.8, demonstrate increased mercury concentrations in fish from lakes with lower pH in the Haliburton area of Ontario. It was further shown that for lakes with similar pH, the mercury was higher in fish from lakes with a higher ratio of drainage area/lake volume. This result implies that the quantity of mercury from either direct atmospheric deposition or watershed leaching is influencing the mercury concentrations in fish. The surveys have not been carried out long enough to establish any trends with time.

In 1980, the survey was extended to include adult bass which are an important component of the sport fishery.

Bass from six of the nine lakes studied had average mercury concentrations above the Canadian guideline for unlimited human consumption of 500 ng/g. In one lake, the U.S. guideline of 1000 ng/g was exceeded.

6.3.5 Leaching of Aluminum

Acidic precipitation has the potential of increasing the leaching rate of material from the watershed. Aluminum is a major constitutent of the bedrock material in the Precambrian area and it tends to be dissolved by acidic runoff. Scheider[22] reported an average total aluminum concentration of 49 µg/l for the study lakes at Dorset. Concentrations in streams are typically up to 200 - 300 µg/l with some measurements exceeding 500 µg/l particularly in the spring runoff (Scheider, pers. comm.).

Laboratory experiments have shown that survival of brook trout was reduced to less than 50% after 14 days at aluminum concentrations of 420 and 480 µg/l at pH values of 5.2 and 4.4 respectively.[13]

It appears that the pH and aluminum concentrations being observed in the Dorset study lakes during spring snow melt fall within the ranges which laboratory experiments have shown to be lethal to fish. It is quite possible that the observed fish kills and apparently altered age distribution of white suckers are due to the combination of pH and aluminum.

6.3.6 Algal Growth

The algae growing in acid stressed and acidic lakes undergo species changes which are detrimental to the recreational use of the lakes and which pose a threat to the habitat of some aquatic organisms. For example, lakes with reduced pH support a proliferation of algae attached to the bottom. The technical term is benthic filamentous algae. This algae can coat gravel fish spawning beds making successful spawning impossible. Significant growths of these algae have been observed in Muskoka-Haliburton lakes such as Plastic, Chub and Leonard.

Another observed change, detrimental to recreational activities, is the appearance of an alga called Chrysochromulina breviturrita Nich. which is characterized by a severe "rotten cabbage" or "garbage dump" odour which has caused lakes to be unsuitable for swimming. The alga has reached problem concentrations in four lakes in Ontario and one in New Hampshire in the past three years. Crosson Lake has experienced the problem. Dickie Lake had an extreme problem in 1979 and it has had cottagers there for over 20 years with no previous observations of the odour.[19] The odour is so bad that residents would likely have remembered had it ever occurred before.

The alga has now been identified at various population sizes in over 40 lakes in Ontario, most of which have low pH.

6.3.7 Amphibians

In the Muskoka-Haliburton area, densities of several species of amphibians decrease with increasing acidity of their habitat. Acidic lakes and streams support a smaller breeding population of spring peepers (Hyla crucifer) than more neutral habitats. Deciduous woodland ponds are the typical breeding habitats for Ambystoma salamanders. However, such ponds have been observed in Muskoka-Haliburton to be very acidic with pH's as low as 4.3. These acidic ponds are now seldom used as breeding sites and thus represent a loss of habitat for this species. The hatching success of any eggs laid in these habitats is low.[9]

6.4 Summary of Water Quality Effects

The current acid loadings to parts of the Precambrian rock areas of Ontario, and in particular the important recreational areas of Muskoka and Haliburton, are causing some lakes and rivers to have low pH values for a few weeks during spring melt and for several hours or days during heavy summer and autumn rains. These lakes are regarded as acid-stressed.

From 60% to 90% of the lakes in the Parry Sound Muskoka-Haliburton area (approximately 12,000 to 18,000 lakes) are sensitive to damage by the short term low pH conditions and may also be acidified over a longer period of time to the point where no fish survive.

Intensive studies on the biological effects of the observed water quality damage are being carried out in a small number of lakes. Fish kills have been observed in the most sensitive study lake. The white sucker population appears to be damaged in a less sensitive study lake. A complete year class of fish is missing in a third sensitive study lake. The pH and aluminum conditions may be the cause of the observed fishery conditions. Low pH and coincident high concentrations of aluminum have been observed in streams at values which laboratory experiments have shown to be lethal for fish.

Mercury concentrations are elevated in fish from lakes with pH below about 6.0. There is reason to suspect that increased man-made atmospheric emissions of mercury from coal burning, coupled with acidification of precipitation and surface waters, will lead to higher mercury concentrations in fish and to more lakes being affected.

Any loss or modification of the quality of sport fish is a major concern to the sport fishing industry valued at hundreds of millions of dollars per year in Ontario.

Several study lakes have been observed to have a proliferation of algae attached to the bottom. This algae poses a threat to fish spawning grounds.

Some lakes with low pH have experienced problems with a foul smelling alga which restricts the recreational

use of the lakes. The occurrence of large amounts of this alga appears to be a recent phenomenon and appears to be related to acid-induced low pH conditions in lakes.

The evidence of effects of acid deposition on the aquatic ecosystem suggests that continued deposition, particularly in the absence of sufficient buffering capacity, causes damages and losses, which in the long run, are irreversible.

The acid stressed lakes under study are showing a number of examples of biological damage. It is nearly certain that similar damage is being experienced by the thousands of lakes with similar alkalinity values and hence, they are experiencing similar water quality effects of acidic runoff in the spring and during heavy rains.

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7.

SIGNIFICANCE TO ONTARIO OF THE EMISSIONS FROM THE 20 POWER PLANTS

7.1 How the Contributions Are Assessed

Information about the twenty U.S. power plants included in these proceedings is listed in Table 7.1 including: the SO_2 emissions allowed under the current (1979) SIP regulations*, the proposed increase above the 1979 regulations, and an estimate of the actual 1979 SO_2 emissions.[1]

This chapter uses this information to assess the significance of the proposed SIP changes to sensitive areas of Ontario. The assessment is based on the Ontario Ministry of Environment statistical model[2] for the long-term, long-range transport of sulphur pollution. The model estimates of sulphur, deposited during precipitation (i.e. wet deposition of sulphur), have been verified using documented experimental results from several monitoring networks for 1977-78. It was found that all model predictions were within a factor of two of the observed values and over 60% of the model estimates were within 35% of the expected values.

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*For Docket No. 5A-79-1 we use August 27, 1976 SIP emission limits for the Eastlake and Avon Lake Plants (i.e. 1.43 and 1.15 lbs. SO_2/MBTU respectively) as the base and oppose any relaxation thereof.

Table 7.1: U.S. Coal-Burning Power Plants Proposing an Increase in their SO_2 Emission Limits

NOTE: All figures are in thousands of metric tons.

	STATE Power Plant	Amount Allowable Under 1979 Regulation	Proposed Increase In Emissions Above Regulation	Proposed Total Emissions	Estimated 1979 SO_2 Emissions
	ILLINOIS				
1)	Baldwin	228.7	54.4	283.1	257.9
	INDIANA				
2)	Clifty Creek	46.2	174.5	220.7	263.7
3)	Tanners Creek	26.1	116.6	142.7	85.2
4)	Michigan City	17.0	84.1	101.1	62.4
5)	Culley	12.5	50.4	62.9	61.3
6)	Bailly	13.9	46.6	60.5	58.0
7)	Stout, Elmer W.	17.6	72.2	89.8	44.2
8)	Warrick	4.3	111.7	116.0	20.2
9)	Mitchell, Dean H.	13.6	62.2	75.8	19.2
	MICHIGAN				
10)	Cobb	40.3	20.2	60.5	69.3
11)	Campbell	39.2	19.5	58.7	57.0
	OHIO				
12)	Muskingham	235.0	150.5	385.5	340.2
13)	Cardinal	214.1	68.6	282.7	140.8
14)	Beckjord	136.0	9.2	145.2	99.7
15)	Poston	16.3	16.3	32.6	29.1
16)	Bayshore	19.3	16.2	35.5	23.7
17)	Avon Lake	26.0	111.4	137.4	98.0
18)	Eastlake	36.5	131.4	167.9	137.4
	TENNESEE				
19)	Kingston	51.0	90.2	141.2	87.2
	WEST VIRGINIA				
20)	Kammer	63.6	157.3	220.8	136.8
	TOTAL	1257.2	1563.5	2820.7	2091.3

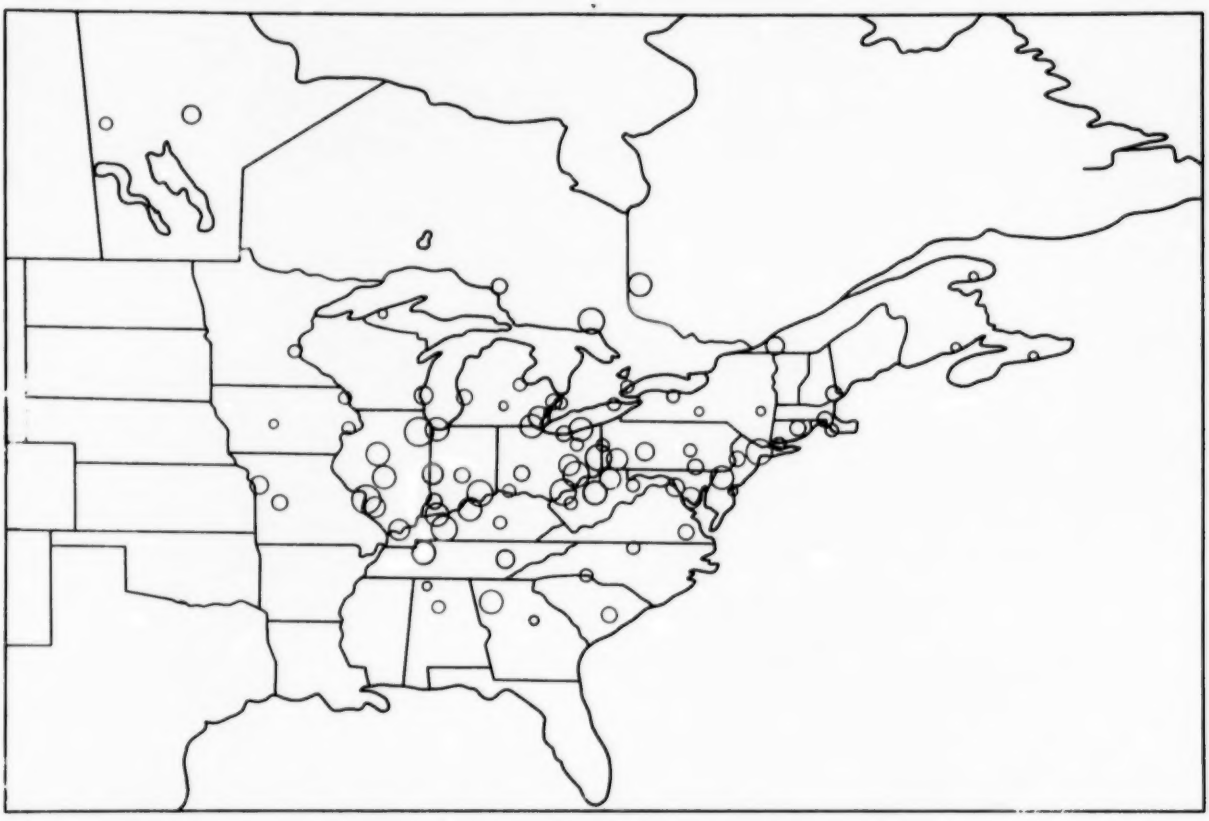

Figure 7.1 Distribution and relative magnitude of the emission inventory for 1979.

LEGEND

Circled area represents source strength

- 100 K TONNES/YR
- 200 K TONNES/YR
- 300 K TONNES/YR
- 400 K TONNES/YR
- 500 K TONNES/YR
- 600 K TONNES/YR
- 700 K TONNES/YR
- 800 K TONNES/YR

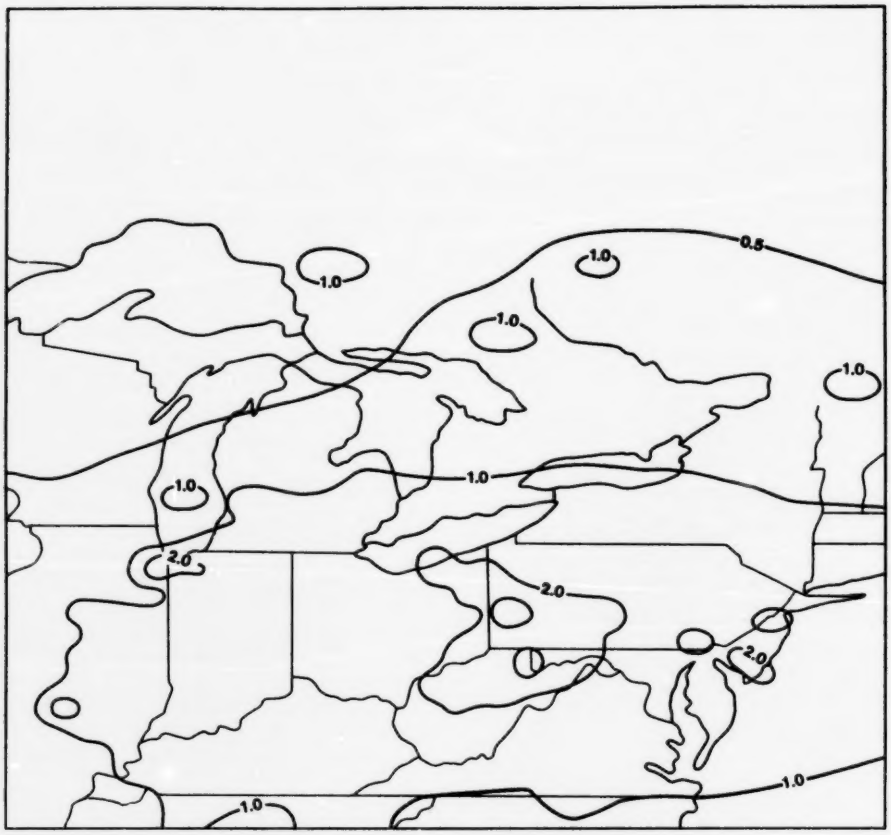

Figure 7.2 Total annual wet deposition of sulphur (gm/m²/yr) due to all SO_2 emissions shown in Figure 7.1 and including a background deposition of 0.2 g/m²/yr to account for sources not in the inventory and biogenic sulphur emissions.

Acidity in precipitation is caused by the hydrogen (H^+) ion and is due primarly to sulphuric acid (H_2SO_4) nitric acid (HNO_3) and ammonium bisulphate (NH_4HSO_4). Measurements in eastern North America have shown a high correlation between the concentrations of the H^+ ions and $SO_4^=$ ions present in precipitation.[3] Therefore, while this model deals only with the amount of wet deposition of sulphur, it can be inferred to be also a good indication of the precipitation acidity.

The model needs an inventory of SO_2 sources as input. The distribution and relative magnitude of points in the SO_2 emission inventory for 1979 are illustrated in Figure 7.1. Figure 7.2 shows the calculated total annual deposition of sulphur during precipitation from these sources. The total annual wet deposition rate is highest in the industrial regions of Ohio, West Virgina and Pennsylvania where it exceeds 3 $g/m^2/yr$. This deposition rate includes a background contribution rate of 0.2 $g/m^2/yr$ which has been added to the model estimate to incorporate the effects of sources not in the model inventory, and to account for biogenic sulphur emissions.[2]

7.2 Actual 1979 Emissions and Their Contributions to Ontario's Wet Deposition

Figure 7.3 shows the location of the 20 power plants proposing an increase in their SO_2 emission

limits. The area of each point source is proportional to the magnitude of the actual 1979 SO_2 emission value. The contribution to wet deposition due to the actual 1979 emissions of these power plants as compared to the total annual wet deposition of sulphur from all sources is displayed in Figure 7.4, as a percentage. The results show that:

- The largest contribution from these plants occurred in the southern portions of Illinois, Indiana and Ohio, near large emitters.
- In the environmentally sensitive Ontario regions of Muskoka-Haliburton and Algoma, these plants contributed between 2.5 - 6.0% of the sulphur deposited in precipitation.
- Column 1 of Table 7.2 summarizes the contribution of the 20 plants to the total wet deposition in these and other sensitive areas in the Great Lakes region.

7.3 Contributions Occurring if the SIP's Had Been Obeyed

The contributions which would have occurred if the 1979 emissions from these 20 plants had been held to their legal limits (as prescribed by various current SIP's) will now be discussed. Figure 7.5 shows these contributions, and Figure 7.6 shows the percentage difference between actual, and SIP-limited cases. The differences are calculated as follows. Wet deposition values from the case using (a) the 1979 SIP-limited emissions from the 20 plants and (b) actual 1979 emissions from the rest of the sources in the airshed are subtracted from the wet deposition values computed in the case where all plants emitted at their

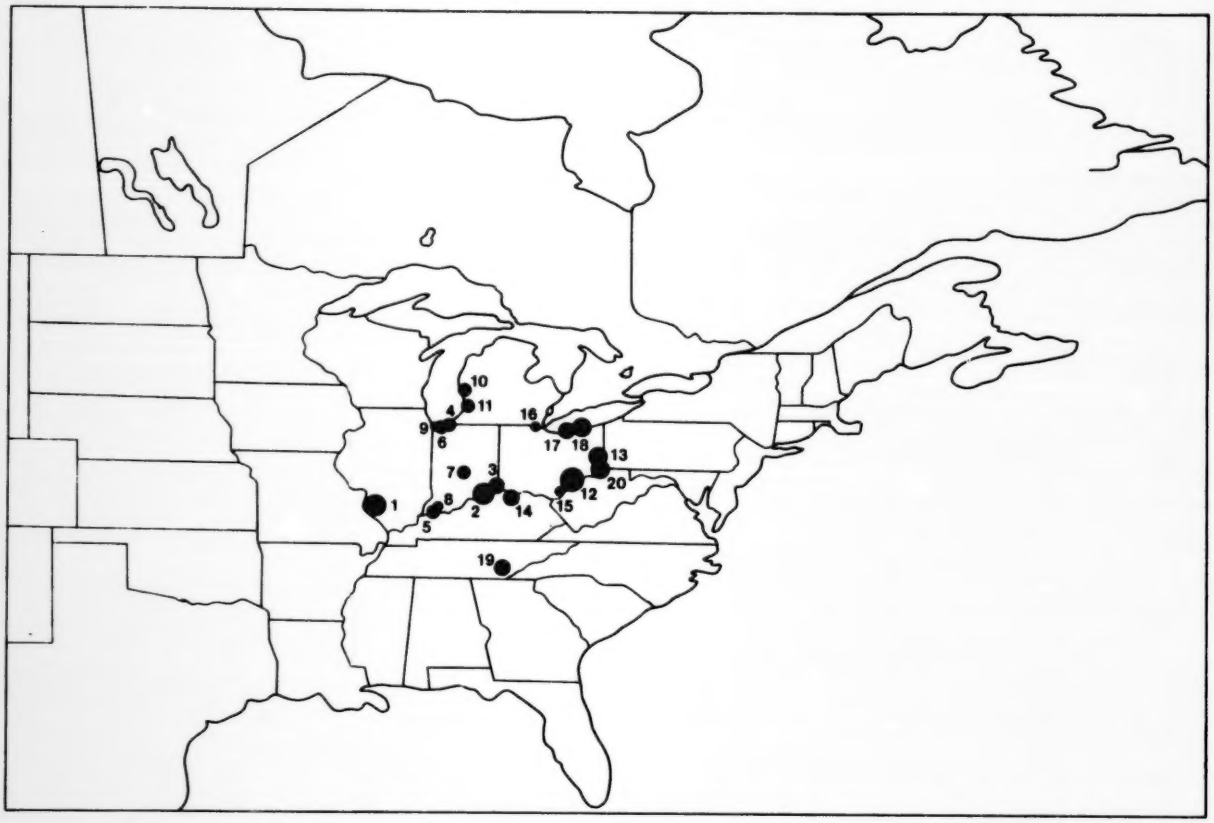

Figure 7.3 Distribution and relative magnitude of the 1979 SO_2 emissions of the U. S. power plants proposing an increase in their regulated SO_2 emission limits.

LEGEND

Circled area represents source strength

- 100 K TONNES/YR
- 200 K TONNES/YR
- 300 K TONNES/YR
- 400 K TONNES/YR
- 500 K TONNES/YR
- 600 K TONNES/YR

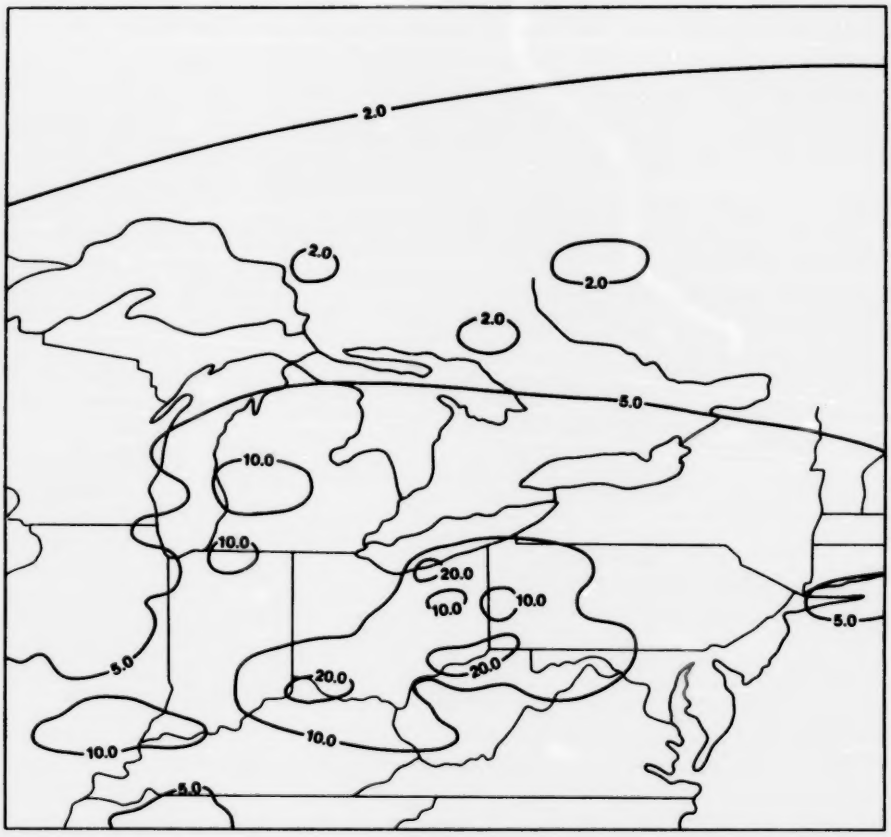

Figure 7.4 Relative contribution (in percent) of the 1979 SO_2 emission of the of the 20 U. S. power plants being studied to the total annual wet deposition of sulphur.

Table 7.2: Contributions of Wet Sulphur Deposition From 20 U.S. Power Plants Under Various Emission Cases to Environmentally Sensitive Areas in Canada and the U.S.

Note: Each column presents data connected with plants' emissions, as described. In all cases, the data are expressed as wet deposition percentages, with the normalizing factor being the total wet deposition occurring in 1979 due to actual emissions from all sources.

Note: Model predictions have been verified to be accurate within a factor of 2 with 60% of the estimates being within 35% of expected values. The range of values given in the text are derived from the figures below.

Sensitive Region	Amount due to actual 1979 emissions	Decrease occurring if 1979 actual emissions were reduced to 1979 SIP maximums.	Increase occurring if emissions rise from 1979 SIP maximum to proposed maximum.	Increase occurring if emissions rise from actual 1979 levels to proposed new limits.	Amount due to emissions if they are held at 1979 SIP limits (Column 1 minus Column 2)	Amount due to emissions if they rise to proposed new limits (Column 1 plus Column 4)
Muskoka-Haliburton, Ontario	4.5	2.0	3.4	1.4	2.5	5.9
Algoma, Ont.	3.0	1.3	2.2	0.9	1.7	3.9
Lakehead, Ont.	1.9	0.8	1.4	0.7	1.1	2.6
Val D'or, Que.	2.7	1.1	2.0	0.8	1.6	3.5
Adirondacks, N.Y.	5.5	2.3	4.3	1.9	3.2	7.4
West Pennsylvania	11.4	3.4	8.5	5.0	8.0	16.5

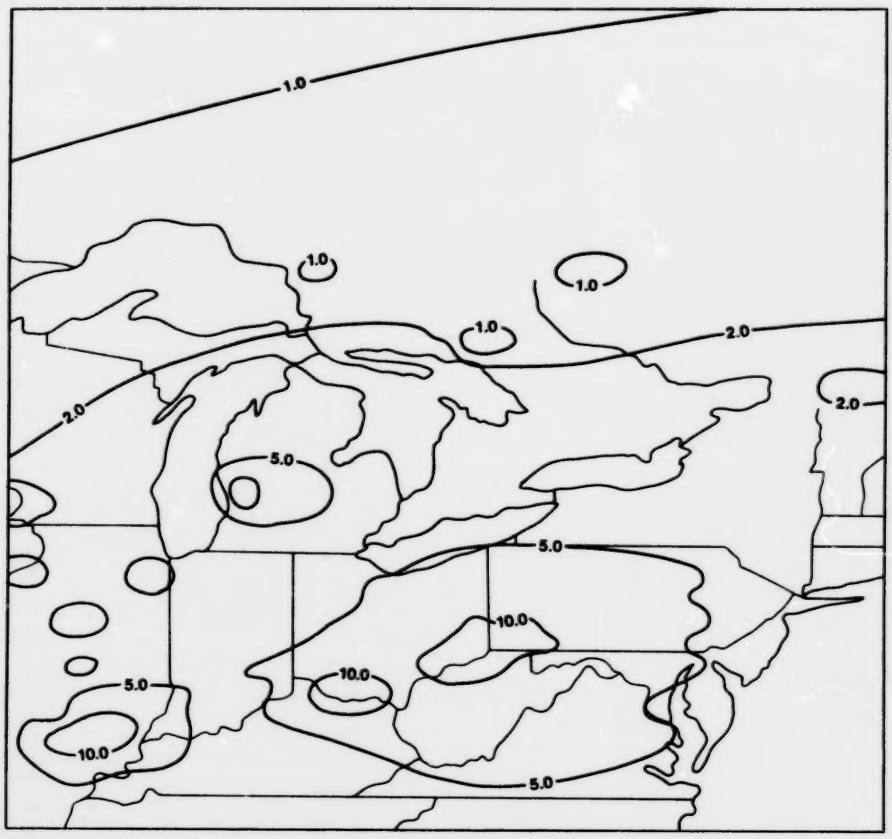

Figure 7.5 Percentage contribution of the 20 U. S. power plants being studied to the total annual wet deposition of sulphur if they emitted the amount of SO_2 allowable under 1979 regulations.

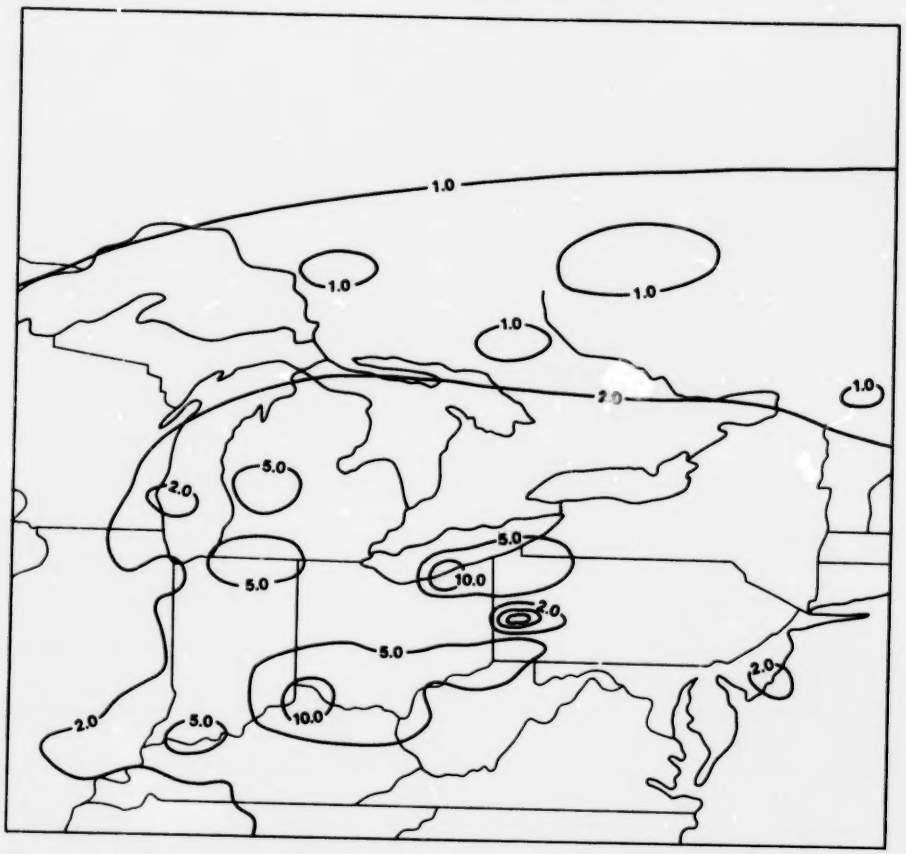

Figure 7.6 Difference between the contribution of the 1979 SO_2 emissions and the contribution of the 1979 regulation emissions of the 20 power plants under consideration (1979 Emissions–1979 Regulations), shown as a percentage of the 1979 total wet deposition of sulphur.

actual 1979 levels. These differences are divided by the values of the latter cases to form a percentage. The results show that:

- In Muskoka-Haliburton, the contribution drops by 1.5 - 2.5% when the 20 plants obey the current SIP's.
- In Algoma, the contribution drops by 0.7 - 1.7% when the 20 plants obey the current SIP's.
- Column 2, Table 7.2 summarizes this analysis for other sensitive regions of the northeastern part of the continent.

7.4 Contributions Which Will Occur if Emissions Rise to the New Proposed Limits

Figure 7.7 shows the percentage contribution of the wet sulphur deposition from these 20 plants which will occur if these plants increase their emissions to the new proposed SIP limits, while all other sources emit at their actual 1979 levels. Figure 7.8 shows the difference between two cases; i.e. the one involving emissions occurring at the new proposed limit levels and the one involving actual 1979 emissions. Finally, Figure 7.9 shows the difference between two other cases; i.e. the one involving emissions at levels occurring if the current SIP's are obeyed and that occurring at the proposed limited levels. The results show that:

In Muskoka, emissions from the 20 plants occurring at the proposed new limits will account for 4.5 - 8.5% of the total from all sources. This is 0.8 - 1.8% more than the actual 1979 emissions case, and 2.0 - 4.0% more than the case where current SIP limits are obeyed.

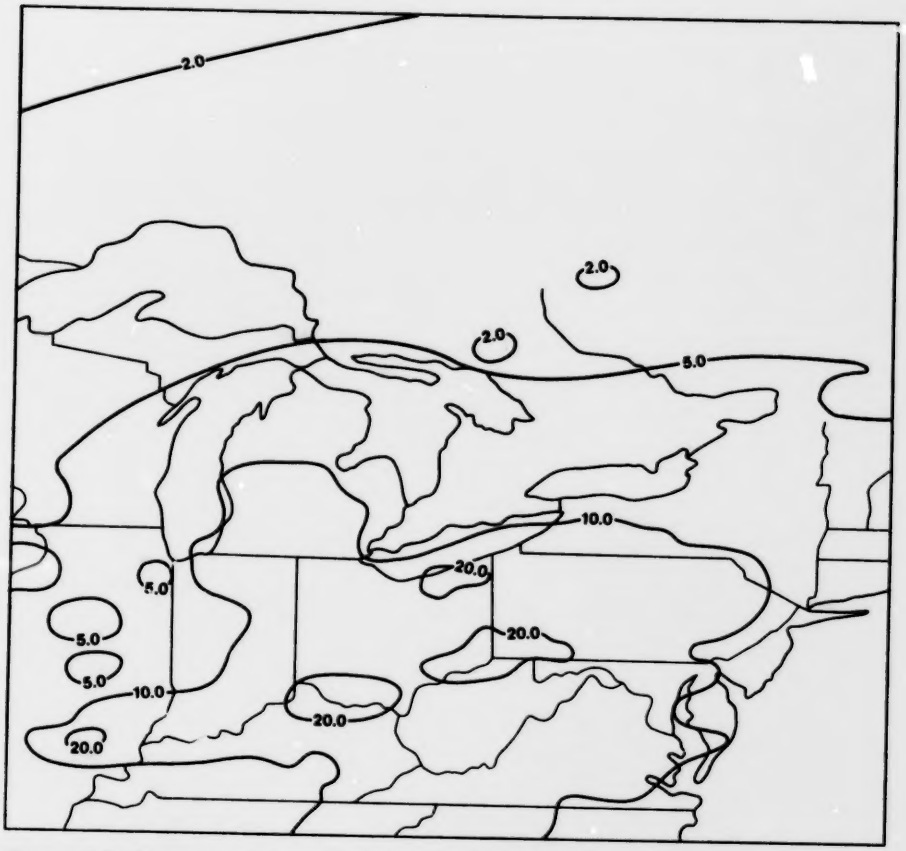

Figure 7.7 Percentage contribution of the 20 power plants under consideration to the total annual wet deposition of sulphur if their SO_2 emission is equal to the proposed new limits.

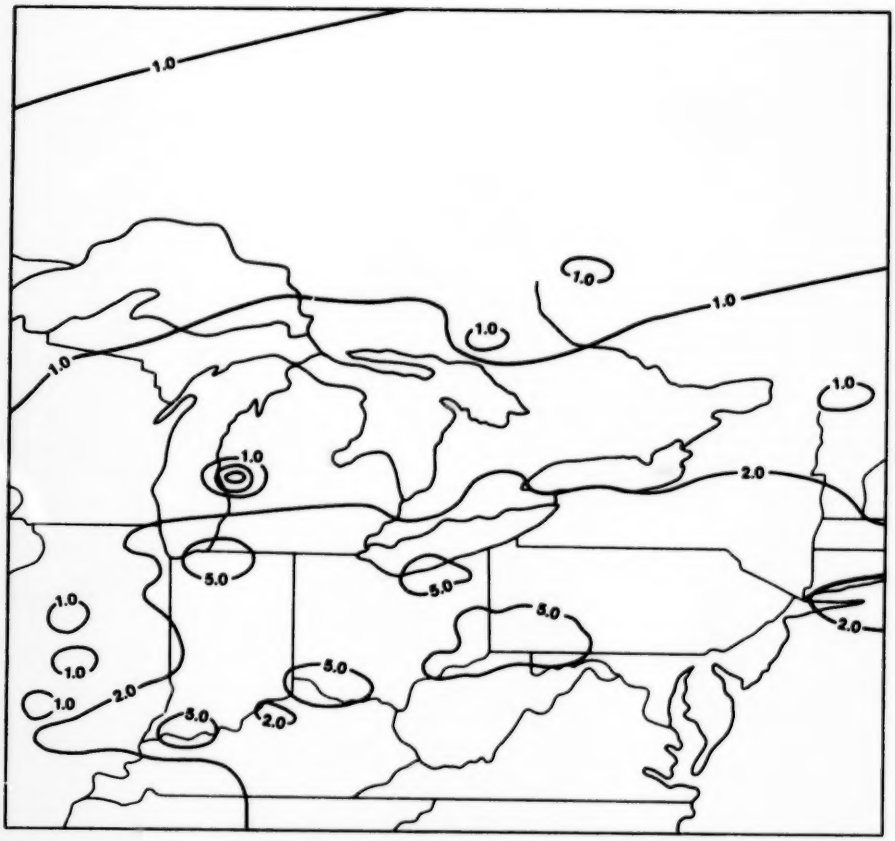

Figure 7.8 Difference in contribution between the case in which emissions of the 20 plants reached the proposed limits and the case for the actual 1979 emissions. Results expressed as percent of the 1979 sulphur deposition.

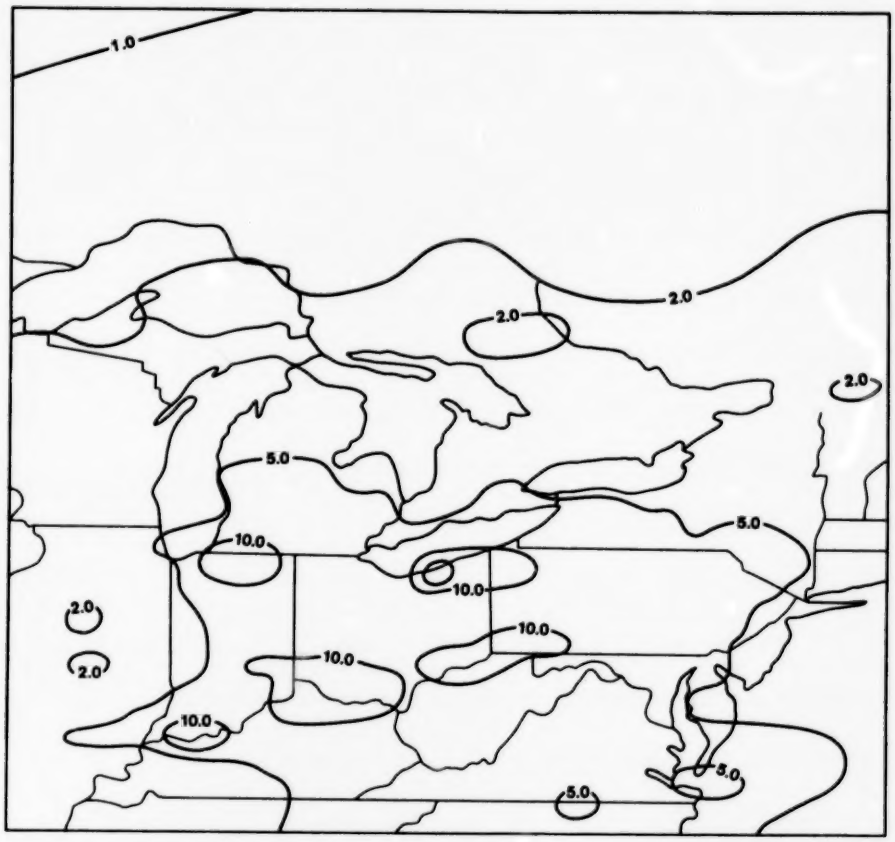

Figure 7.9 The difference in contribution between the case in which the emissions from the plants reached the proposed limits and for the case in which the plants emissions met SIP 1979 Regulation limits. Results expressed as a per cent of the 1979 sulphur deposition.

- Similarly, in Algoma the same proposed emissions levels account for 3.3 - 5.8% of the total due to all sources. This is 0.5 - 1.5% more than the actual 1979 emissions case, and 1.6 - 2.8% more than the case of obeying the current SIP limits.

- Columns 3 and 4 of Table 7.2 list the analysis results for other sensitive receptor areas.

- Columns 5 and 6 of Table 7.2 show the percent contribution to these areas if the new limits were reached by the 20 sources, and in comparison, the contributions arising from obeying the current SIP's.

7.5 Summary

It is clear from this discussion that the contribution to Ontario's environmentally sensitive areas by the 20 plants in question will more than double if emissions rise along with the SIP limits. The contributions in the case of the new limits will form a significant part of the damage to Ontario's environment.

It is also clear that enforcement of the original SIP's by EPA would reduce the deposition in Ontario and help reduce ecological damage.

While all of this analysis has been performed for wet deposition, results would be very similar for dry deposition, because the spatial distribution of dry deposition is similar to that of wet deposition, and the amounts of wet and dry deposition are usually similar.[4,5,6] The dry deposition component can be modelled, but the estimates cannot be verified by field measurements at the present time.

REFERENCES - CHAPTER 7

1. The 1979 SO_2 estimates are based on the information contained in

   a) Cost & Quality of Fuels for Electric Utility Plants-1979. Energy Data Report. FPC. Form No. 423. DOE/EIA-0191 (79), June, 1980.

   b) Federal Power Commission, Form F "Monthly Power Plant Report" (F.E.R.C. Form No. 4), January - December, 1979.

   c) AP-42 Compilation of Air Pollutant Emission Factors.

2. VENKATRAM, A., LEY B.E., and WONG, S.Y. 1980: A Statistical Model to Estimate Long-Term Concentration of Pollutants Associated with Long Range Transport. Ontario Ministry of the Environment Internal Report. (Accepted for publication in Atmospheric Environment).

3. BARRIE, L. 1981: The Prediction of Rain Acidity and SO_2 Scavenging in Eastern North America. Atm. Env., 15, 31.

4. SLINN, W.G.N. 1977: Some Approximations for the Wet and Dry Removal of Particles and Gases from the Atmosphere. Water, Air & Soil Poll., 7, 513.

5. GARLAND, J.A. 1978: Dry and Wet Removal of Sulphur from the Atmosphere. Atm. Env., 12, 349.

6. GALLOWAY, J.N. and WHELPDALE, D.M. 1980: An Atmospheric Sulphur Budget for Eastern North America. Atm. Env. 14, 409.

ONTARIO'S ACTIVITIES TO REDUCE SO_2 EMISSIONS

It is the objective of the Ontario government to reduce acid deposition as far as possible. To this end, Ontario is protecting its environment and that of its neighbours by reducing its own SO_2 emissions, as well as pressing for a reduction from sources in neighbouring provinces and states.

8.1 Cutbacks of Sources Within Ontario

8.1.1 INCO Ltd. Operations, Sudbury

INCO's Sudbury operations have reduced emissions from approximately 2.0 million metric tons per year in 1969 to a maximum of 1.2 million metric tons per year in early 1978.

Between mid-1978 and early 1980, INCO was under a Control Order limiting emissions of SO_2 to 1.2 million metric tons per year.

In May 1980, Ontario re-evaluated the 1978 control program based on the need to provide greater controls on SO_2 emissions in order to reduce acid deposition. Consequently, the Control Order was amended and a Regulation[1] issued (see

EXHIBIT 8.1

Publications Under The Regulations Act

September 20th, 1980

THE ENVIRONMENTAL PROTECTION ACT, 1971

O. Reg. 712/80.
Copper Cliff Smelter Complex
Made – August 27th, 1980
Filed – September 2nd, 1980

R.O.C. 419/80

Copy of an Order-in-Council approved by Her Honour the Lieutenant Governor, dated the 27th day of August, A.D. 1980

The Committee of Council have had under consideration the report of the Honourable the Minister of the Environment, wherein he states that,

WHEREAS acidic precipitation adversely affects the natural environment, including the lakes and rivers, of the Province of Ontario;

WHEREAS sulphur dioxide emitted from non-ferrous smelting operations is one of the most significant Ontario contributors to the acidic precipitation phenomenon;

WHEREAS Inco Limited's Copper Cliff Smelter Complex in The Regional Municipality of Sudbury is the major source in Ontario of sulphur dioxide emissions and thus contributes to the level of acidic precipitation in Ontario;

WHEREAS questions have arisen regarding particular limits to be placed on the total amount of sulphur dioxide emitted from the Copper Cliff Smelter Complex;

WHEREAS the particular limits in the appended Regulation have been considered by the Executive Council and found to be appropriate;

The Honourable the Minister of the Environment therefore recommends that the appended Regulation be made under *The Environmental Protection Act, 1971*, to protect the natural environment of Ontario and to remove, at the earliest possible time, any uncertainty as to the interim limits which emissions from the Copper Cliff Smelter Complex will be required to meet while studies are going on to determine whether or not any lower limits should be imposed.

The Committee of Council concur in the recommendation of the Honourable the Minister of the Environment and advise that the same be acted on.

14

REGULATION MADE UNDER THE ENVIRONMENTAL PROTECTION ACT, 1971

COPPER CLIFF SMELTER COMPLEX

1. This Regulation applies to Inco Limited and to emissions of sulphur dioxide from the Copper Cliff Smelter Complex of Inco Limited in The Regional Municipality of Sudbury. O. Reg. 712/80, s. 1.

2. In this Regulation,

(a) "ton" means a short ton;

(b) "working day" means any day on which a process unit of the Copper Cliff Smelter Complex receives sulphur-bearing process feed material and emits any sulphur dioxide to the atmosphere. O. Reg. 712/80, s. 2.

3.—(1) Emissions during each of the four periods, each beginning on the day this Regulation is filed and respectively ending at the end of the third and fourth calendar quarters of 1980, and the first and second calendar quarters of 1981, shall not exceed, in the average, 2500 tons per working day.

(2) Emissions during each twelve-month period respectively ending at the end of the third and fourth calendar quarters of 1981, each calendar quarter of 1982 and the first three calendar quarters of 1983, shall not exceed, in the average, 2500 tons per working day.

(3) Emissions during each twelve-month period ending at the end of the fourth calendar quarter of 1983 and each calendar quarter thereafter shall not exceed, in the average, 1950 tons per working day.

(4) For purposes of subsections 1, 2 and 3, the amount of sulphur dioxide emitted on any working day for which an accurate record is kept shall be the amount so recorded and for which an accurate record is not kept shall be deemed to be the greater of,

(a) the number of tons that can be established to have been emitted; or

(b) 2500 tons for a working day up to the 31st day of December, 1982 and 1950 tons for a working day after the 31st day of December, 1982.

(5) Where, in the average, emissions exceed 2500 tons per working day with respect to any period referred to in subsection 1, there shall be deemed to be no contravention of subsection 1 in respect of that period if, in the average, emissions per working day for a period of twelve months ending at the end of that period do not exceed 2500 tons. O. Reg. 712/80, s. 3.

Exhibit 8.1) which in combination with the control order required INCO to:

(a) Limit SO_2 emissions from INCO's Copper Cliff Complex to a maximum of 833,000 metric tons per year.

(b) Limit SO_2 emissions from INCO's Iron Ore Recovery plant so that they do not exceed an average of 83,300 metric tons per year. This average will be computed quarterly over a 12-month production period.

(c) Submit by December 31, 1980, a report detailing the facilities and the implementation schedule necessary to limit SO_2 emissions from the INCO Copper Cliff smelter to 647,000 metric tons per year. These facilities are to be in place by December 31, 1982.

(d) Continue the existing program designed to bring all low level emissions from the company's nickel refinery into compliance with provincial standards as set out in Ontario's Environmental Protection Act. The company must complete installation of the necessary facilities and have these in operation by December 31, 1982.

These limits are of an interim nature. When the results of investigations are known in 1983 these emission limits will be cut further to significantly lower values.

In summary, INCO's emissions have decreased under Government programs by more than 58 per cent since 1969, and they are being reduced by another 22 per cent by the end of 1982.

8.1.2. Falconbridge Nickel Mines Limited

Falconbridge Nickel Mines, Ltd. operates a smelter in Nickel Centre Ontario (near Sudbury). In 1969, their emissions of SO_2 were about 343,000 metric tons per year.

The first Falconbridge Control Order was issued on November 29, 1969. It required a 55% reduction of SO_2 emissions by December 31, 1975, or a cutback from 343,000 to 155,000 metric tons per year.

Due to the failure of the planned technology, a new Control Order was issued in 1973 allowing for emissions to be reduced to 220,000 metric tons per year by December 31, 1976 and 155,000 metric tons per year by May 31, 1979. This was further altered in July of 1977 allowing for an emission level of 280,000 metric tons per year until May 31, 1979, followed by a reduction to 155,000 metric tons per year thereafter.

By the end of 1979, Falconbridge had successfully completed the installation and commissioning of its new equipment to reduce SO_2 emissions. Their actual emissions that year were 89,000 metric tons due to abnormally low operations levels.

In summary, Falconbridge has reduced SO_2 emissions by at least 55% between 1969 and the present.

8.1.3. Ontario Hydro

Ontario Hydro's coal-fired plants together form the second largest emmitter of SO_2 in the Province. (See Table 8.1). On January 26, 1981, the Ontario government issued a Regulation which places annual limits on atmospheric emissions from Hydro's power system. (Copy attached as Exhibit 8.2). As a result of this Regulation, Hydro will immediately begin implementing control activities. Due to the massive size of Hydro's generating facilities and the complexity of the steps to be taken, considerable lead time will be required before the control facilities can become fully operational.

The first part of the Regulation will limit SO_2 emissions to 390,000 metric tons per year beginning in 1985. By 1990, when most of the control measures are fully operational, the limit will drop to a permanent ceiling of 260,000 metric tons of SO_2 per year.

TABLE 8.1

SULPHUR DIOXIDE EMISSIONS FROM ONTARIO
HYDRO THERMAL GENERATING STATIONS

HYDRO G.S.	1979 (METRIC TONS)
LAMBTON Sarnia, Ontario	160,250
NANTICOKE Nanticoke, Ontario	155,080
LAKEVIEW Mississauga, Ontario	91,345
HEARN Toronto, Ontario	10,190
THUNDER BAY Thunder Bay, Ontario	10,035
LENNOX Bath, Ontario	10,010
TOTAL	436,910

NOTE: All stations are coal-fired, except for Hearn, which operates partially on coal and partially on gas, and Lennox, which is oil-fired.

EXHIBIT 8.2

10

THE ENVIRONMENTAL PROTECTION ACT

O. Reg. 73/81.
Ontario Hydro.
Made—February 17th, 1981.
Filed—February 17th, 1981.

REGULATION MADE UNDER THE ENVIRONMENTAL PROTECTION ACT, 1971

ONTARIO HYDRO

1. Emissions of sulphur dioxide from the fossil-fueled electric generating stations of Ontario Hydro shall not exceed, in the aggregate, 390 kilotonnes in the calendar year 1986, 1987, 1988 or 1989. O. Reg. 73/81, s. 1.

2. Emissions of sulphur dioxide from the fossil-fueled electric generating stations of Ontario Hydro shall not exceed, in the aggregate, 260 kilotonnes in any calendar year after 1989. O. Reg. 73/81, s. 2.

3. Emissions of nitric oxide from the fossil-fueled electric generating stations of Ontario Hydro shall not exceed, in the aggregate, sixty kilotonnes in the calendar year 1986, 1987, 1988 or 1989. O. Reg. 73/81, s. 3.

4. Emissions of nitric oxide from the fossil-fueled electric generating stations of Ontario Hydro shall not exceed, in the aggregate, forty kilotonnes in any calendar year after 1989. O. Reg. 73/81, s. 4.

(6758) 10

For comparison, Hydro's emissions were 437,000 metric tons in 1979, and 410,000 metric tons in 1980. They are projected to be about 509,000 tons in 1981. Taking the average of these figures as the measure of Hydro's current level of activity, its emissions average about 452,000 metric tons per year. Therefore, the reduction in 1990 will be about 43 per cent from current levels.

In addition, the Regulation will require Hydro to install low NO_x burners at its larger coal-fired stations. This action should result in a maximum of roughly 60,000 metric tons of NO_x in 1985, and about 40,000 metric tons in 1990. This amount will decline further between 1985 and 1990 because less coal-fired generation will be occurring at the end of this decade.

Ontario Hydro has also been asked to investigate the implementation of a new operating philosophy, designed to minimize atmospheric emissions from Hydro's three biggest coal-fired stations--Nanticoke, Lambton and Lakeview. These three plants account for more than 90 percent of Hydro's SO_2 emissions.

The name of the operating philosophy is the Least Emissions Dispatching System (L.E.D.S.). This concept is being considered by the U.S. Government. If implemented, it would lead to significant reductions in emissions from

existing plants, without the use of any additional pollution control equipment or special fuels. Under the L.E.D.S. philosophy, a utility generates power from its "cleanest" plants first, and its "dirtiest" plants last. This ensures that plants already having pollution control measures are utilized fully, and not allowed to stand idle.

Ontario Hydro has complied with this request and will shortly be producing a report. At that time, a decision will be made as to whether L.E.D.S. should be implemented.

8.2 Negotiation of Agreement Leading to Abatement

On August 5, 1980 the Federal Governments of Canada and the United States signed the "Memorandum of Intent". Ontario is represented on all Work Groups which were formed as a consequence of this action, and is playing a significant role in the formulation of reports coming from these work groups.

All committees were charged with the responsibility of preparing and submitting interim reports by January 15, 1981 and first reports by May 1981. These reports are to form the basis for negotiations scheduled to start late in 1981. The committees are to produce final reports by January 1982.

As part of the technical input to these activities, Ontario is contributing the knowledge and expertise it has developed in its major environmental program, already underway, entitled the "Acidic Precipitation In Ontario Study" (A.P.I.O.S.) which has the following objectives:

(1) To identify and quantify by means of field investigations Ontario's contribution to the atmospheric burden of SO_2 as well as the long range component of this burden;

(2) To develop atmospheric transport models and use them to determine how sources of SO_2 are impacting on sensitive ecological areas;

(3) To quantify the deposition of acidic substances in Ontario;

(4) To assess the terrestrial and aquatic significance of the deposition of acidic substances in Ontario;

(5) To assess socio-economic impacts and options to deal with the phenomenon from the perspective of costs and benefits.

The results of A.P.I.O.S. are also being used to formulate policies in Ontario and in Canada.

8.3 Interim Activities

Ontario has enforced in the past, is currently enforcing and will continue to enforce vigorously its existing regulations. Additionally, Ontario has proceeded with an aggressive program to identify major emission sources which contribute to acid deposition. This program is expanding, updating, and refining the scientific and engineering data base. As these results become available, Ontario is issuing and enforcing new regulations which will further reduce SO_2 emissions.

On the international front, Ontario is undertaking five actions.

First, the Ontario government is participating wholeheartedly in the Canada-United States Working Groups on acid deposition. These scientific groups are laying the foundation for the urgently needed air quality agreement with our American neighbours.

Second, Ontario is pressing the U.S. government to enforce vigorously its existing SO_2 emission standards, as set out in the various State Implementation Plans. This submission comprises one part of this activity.

Third, we are urging adequate evaluation of the cumulative effects of any proposed SIP revisions on Ontario and other provinces.

Fourth, the government of Ontario is opposing any actions by the U.S. and State governments which relax the existing SIP requirements.

Fifth, Ontario seeks to participate in any U.S. proceedings which could effect, as a result of long range transport, our environmental quality.

Ontario is undertaking these five actions because its leadership in reducing acid deposition within its jurisdiction will be of little consequence unless other jurisdictions follow this lead, due to the nature of the problem, that is, the transboundary exchange of pollutants between Canada and the United States. Canada receives two to four times the amount of SO_x from the U.S. than it sends to the U.S., and the NO_x exchange is 11 times greater from the United States to Canada.[2]

A review of emission trends from U.S. sources over the past forty years clarifies and substantiates this statement. First and foremost, SO_2 emissions have increased by about forty percent. Although SO_2 emissions have decreased

from most economic sectors during this period, the electric utility sector's emissions increased by more than a factor of six during this same period.[3] Second, the increase in SO_2 emissions from this one sector occurred concurrently with a substantial increase (by approximately a factor of five) in the stack height for utility sources.[4] Third, SO_2 emissions from coal burning changed from a wintertime peak to a more level rate throughout the year, with a small peak in the summer emission rate.[5] Fourth, the precursor emissions for photochemical oxidants increased markedly during this time.[3] In the earlier parts of this century, photochemical smog was hardly recognizable as a problem. Now, however, photochemically-produced oxidants frequently blanket the continental Northeast during the summer months.[6] Fifth, total NO_x emissions approximately quadrupled during this period.[3]

These trends suggest a situation in which the atmosphere has become chemically more reactive. Simultaneously, greater quantities of acid-forming precursors are being added to the atmosphere. Further, a substantially greater quantity of these emissions is now injected high into the mixed layer where the emissions and their reaction products have much longer residence times as they travel to areas remote from their points of origin.

In Ontario, there is firm scientific evidence that if these emissions of sulphur dioxide <u>continue</u>, or

increase, the resultant acidic pollutants are threatening to kill aquatic life in thousands of Ontario lakes and waterways within the brief span of another 10 to 20 years. Serious concern also exists that damage to terrestrial life forms may also occur, and that man-made structures will be impacted.

With the substantial increase in the use of coal as a source of energy in the United States, and the projected increases in SO_2 and NO_x emissions in the U.S. between now and the year 2000, controls to reduce existing U.S. utility emissions are vital to the protection of Ontario's environment and that of Eastern Canada. The United States SO_2 emissions from power utilities are estimated at 18.6 million metric tons annually,[2] accounting for roughly two-thirds of total SO_2 emissions--compared with total SO_2 power utility emissions in Canada of 700,000[7] metric tons annually.

In summary, because transboundary pollution is of critical concern to Ontario and Canada's eastern provinces, there is an immediate need to reduce the emissions of these serious pollutants from existing U.S. power plants as well as the hundreds of new plants which are expected to be built in the United States during the next two decades.

REFERENCES - CHAPTER 8

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REMEDIES SOUGHT

ONTARIO, THEREFORE, URGES:

9.1. (a) That the Administrator disapprove any SIP revisions in those proceedings which would result in any increase of permissible emissions of SO_2.

(b) That the Administrator reconsider any SIP revisions already approved in these proceedings which result in any increase of permissible emissions of SO_2 and disapprove such revisions.

(c) That, the Administrator disapprove any future SIP revisions allowing increased SO_2 emissions which he may be called upon to consider.

9.2 That, in the event that the Administrator does not disapprove such revisions, he should, prior to making a decision, reopen and consolidate these proceedings and evaluate the cumulative effect of such revisions on Ontario and other Provinces and he should permit Ontario to participate in such reopened proceedings. Included in any such evaluation and consolidation should be any other SIP revisions which involve relaxations of SO_2 emissions that the Administrator may be called

upon to consider.

9.3 That, in any event, the Administrator take all steps necessary to assure effective enforcement of existing SO_2 emission standards.